ASTRONOMY

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Probing the Orion Nebula

Plot Star Maps on Your Computer

How to Find and Photograph Halley's Comet

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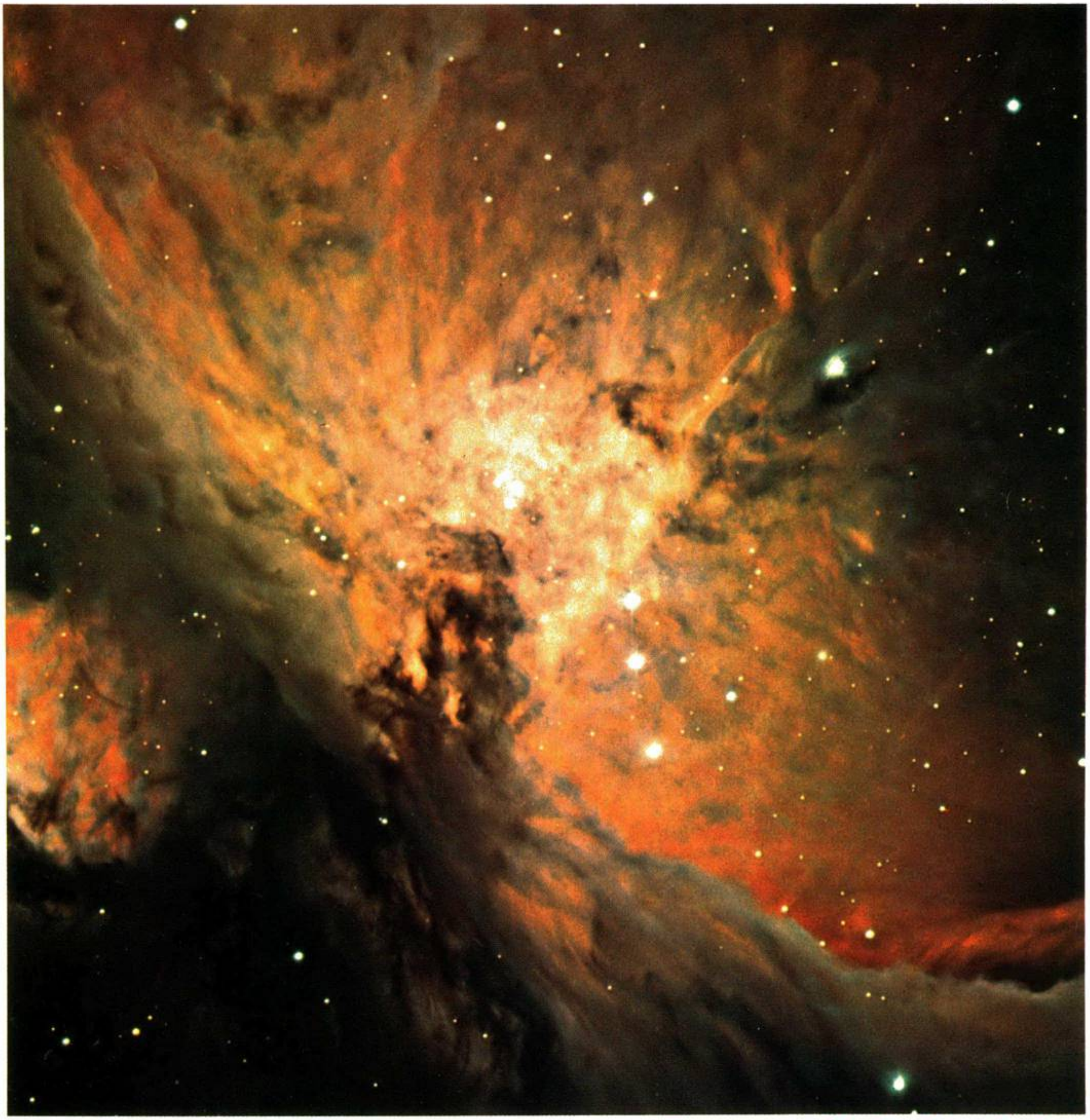

Great Nebula in Orion

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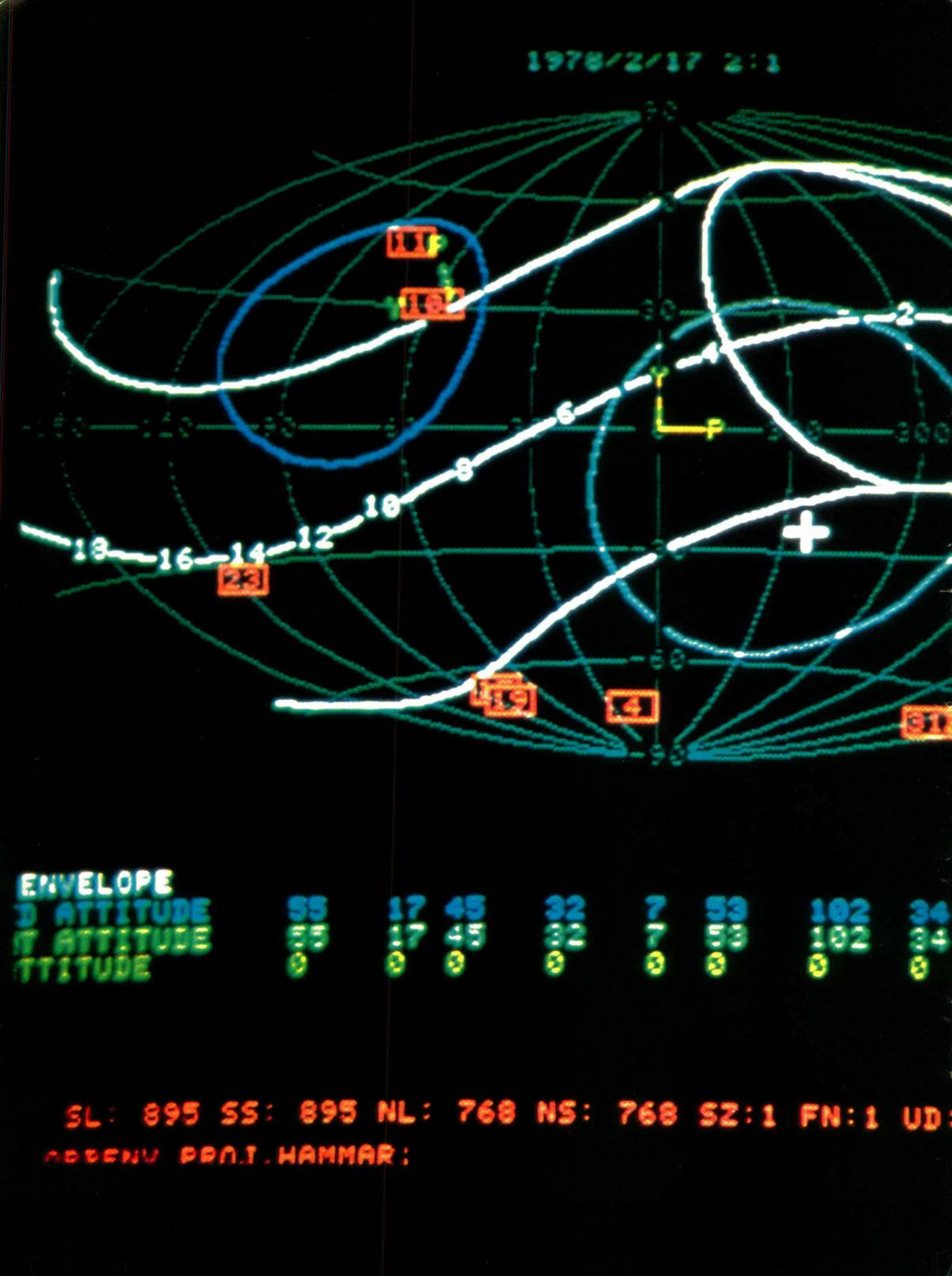

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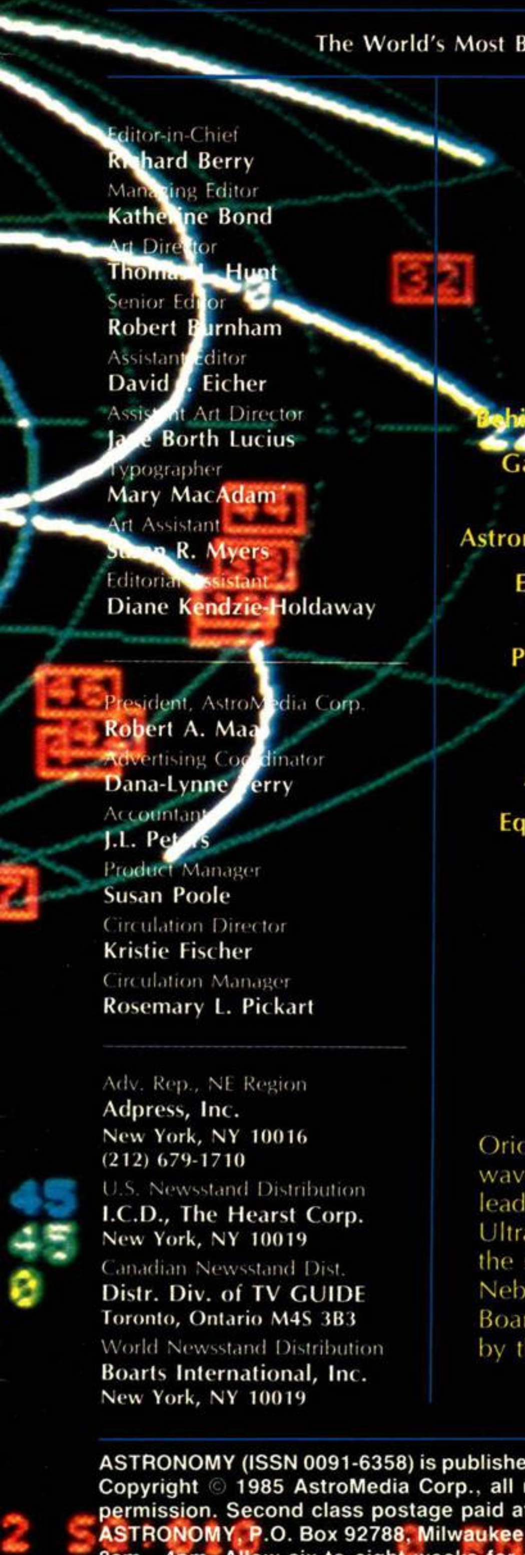

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Cover: Large, bright, and relatively nearby, the Great Nebula in Orion has been probed by astronomers with instruments working at all wavelengths — radio, infrared, visible, ultraviolet, X-ray, and gamma-ray. Our lead article this month takes you into the control room of the International Ultraviolet Explorer (IUE) — a satellite observatory — where you'll peek over the shoulders of astronomers who are working to unravel some of the Orion Nebula's secrets. Photograph © 1981 by the Anglo-Australian Telescope Board. These pages: A computer-graphic readout of the region of sky surveyed by the IUE. NASA photo.

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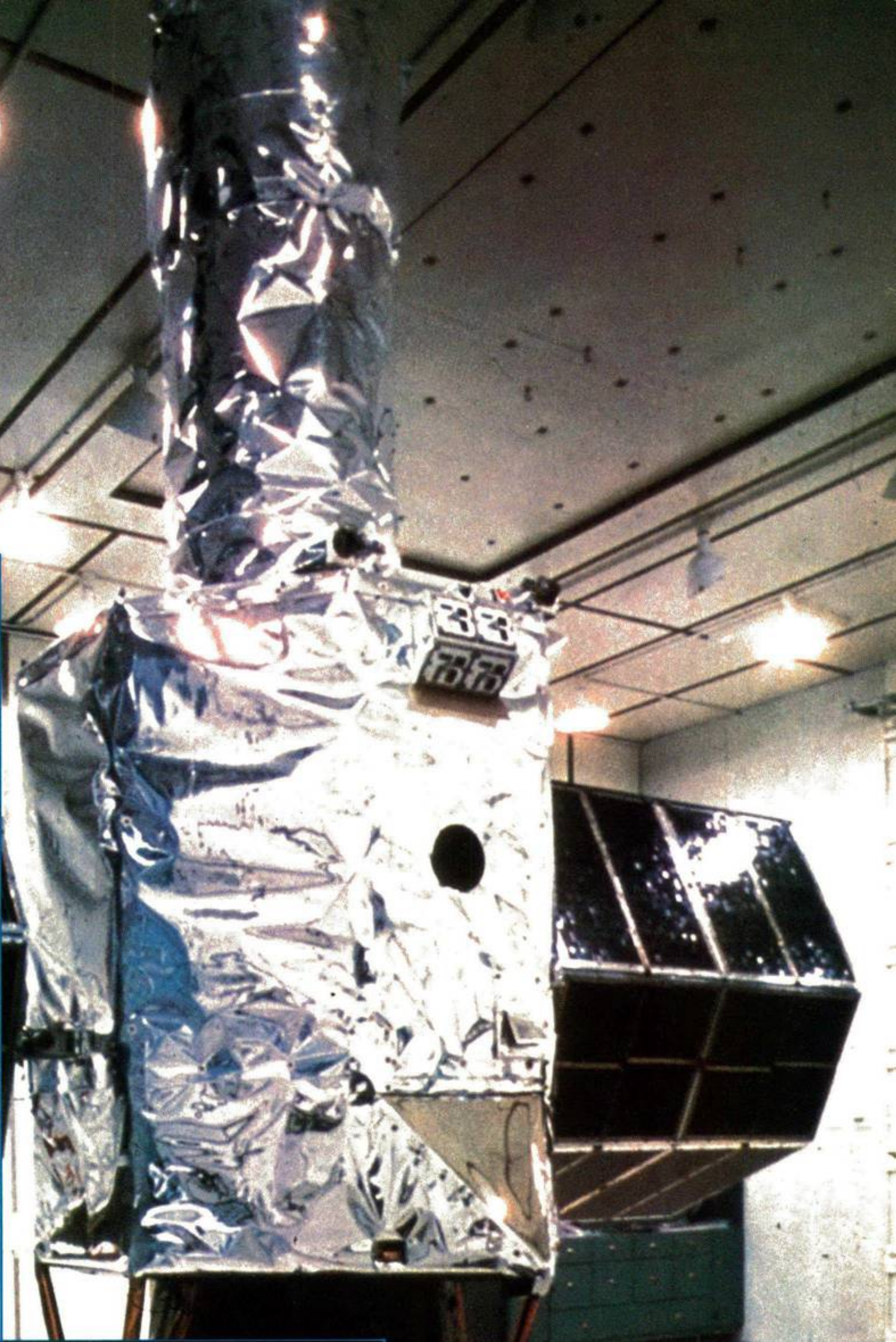
Probing the Orion Nebula with the IUE

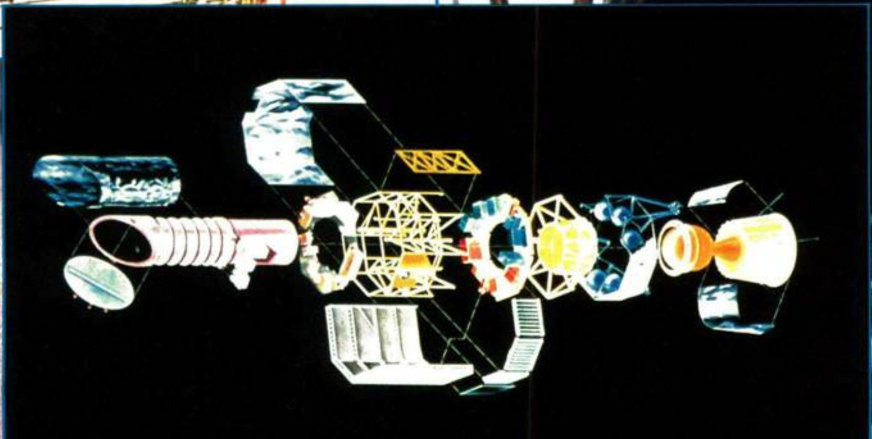
by Peter Perry and Barry Turnrose

The core of the Orion Nebula is a turbulent mixture of hot stars, ionized gases, and opaque dust. The IUE satellite observatory can explore the structure of the hot gases at ultraviolet wavelengths. Photograph © 1981 by the Anglo-Australian Telescope Board.

January 26, 1978 — launch of the IUE from Cape Canaveral.



Testing the IUE before launch — black solar panels and silvery foil insulation.



NASA

An exploded view — at the heart of the satellite observatory is an 18-inch telescope.

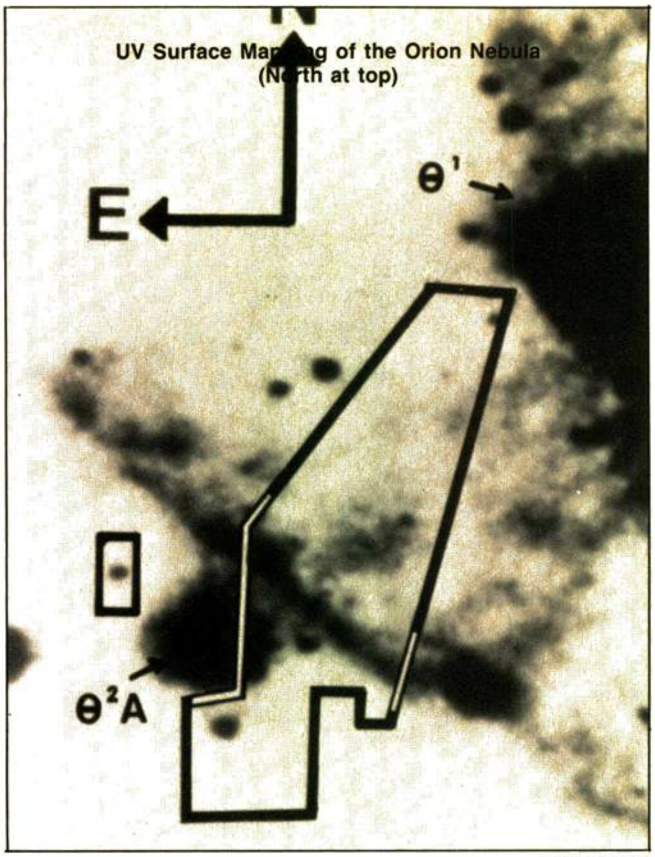
On clear, crisp January nights, the panorama of the winter sky unfolds before you. Stars seem spectacularly bright: low in the southeast flashes blue-white Sirius. As your eye tracks westward, orange Betelgeuse attracts your attention. Moving on, you are struck by ruddy Aldebaran in the constellation of Taurus. Farther west, the tiny silver dipper of the Pleiades catches your eye. You've seen this display many times before, but it still seems fresh and exhilarating. Your gaze returns to Betelgeuse. Drifting southward, you pick out three familiar stars lined neatly in a row. This is the Belt of the constellation of Orion, the Hunter. A few degrees south of the Belt, you strain to see the fuzzy "star" that is the Great Nebula in Orion.

People have been straining to make out this fuzzy star for centuries. Not only straining to resolve it visually, but also straining to unravel its mysteries. On viewing this object in a telescope, you are immediately struck by its gossamer structure — something you never see in the otherwise spectacular photographs often published. What is this tenuous glowing object really composed of? Even to the casual observer, it appears in a great state of turmoil. Is this really so? And what about the stars within the nebula — are they part of it? Or are they innocent bystanders merely caught up in the line of sight? Questions like these have long puzzled astronomers. With the construction of each newer, bigger, or better telescope, they have eagerly returned to the Orion Nebula to see if yet another of its secrets can be pried loose.

One of the most advanced "observatories" to work on this nebula is the IUE satellite. (IUE, pronounced "eye-you-ee," stands for International Ultraviolet Explorer.) The IUE is a space-borne telescope designed to observe the spectra of celestial objects in ultraviolet light, inaccessible from the ground because of the Earth's atmosphere.

The IUE is operated jointed by the National Aeronautics and Space Administration, the European Space Agency (ESA), and the United Kingdom's Science and Engineering Research Council. The satellite was launched on January 26, 1978 and follows an eccentric 24-hour orbit. The once-a-day orbit allows "real time" observations from either of two ground stations: a NASA station at Goddard Space Flight Center in Greenbelt, Maryland, and an ESA station at Villafranca del Castillo near Madrid, Spain. The IUE's scientific instrument consists of a 45-centimeter diameter (18-inch) telescope coupled to two spectrographs, each capable of low-resolution (6 Angstroms) or high-resolution (0.1 A) operation. It is sensitive to wavelengths between 1100 A and 3200 A. Television cameras image the spectra and transmit them back to the ground. Any astronomer who wishes to observe with the IUE must submit a research proposal, which is then carefully evaluated for scientific merit and technical feasibility. Since early 1978, hundreds of astronomers have observed with the IUE, obtaining about 40,000 spectra of stars, planets, galaxies, quasars, nebulae, and comets.

Astronomers using the IUE satellite through the U.S. ground station arrive at Goddard Space Flight Center a day or two before the observing run begins. There they meet the resident staff and complete final preparations. As you walk down the long hallway on the ground floor of the Space Center's Building 21, you find the observatory's focal point: two modern control rooms with large glass windows. These flank a central reception area and staff offices. The central rooms, the telescope operations control center, and the image processing control center make up the core of the observatory. They contain computers and consoles linking the observer and support staff with the IUE operations control center, which houses the main computers and the engineering staff. In turn, the operations control center provides the link to an antenna network which sends and receives data from the spacecraft.

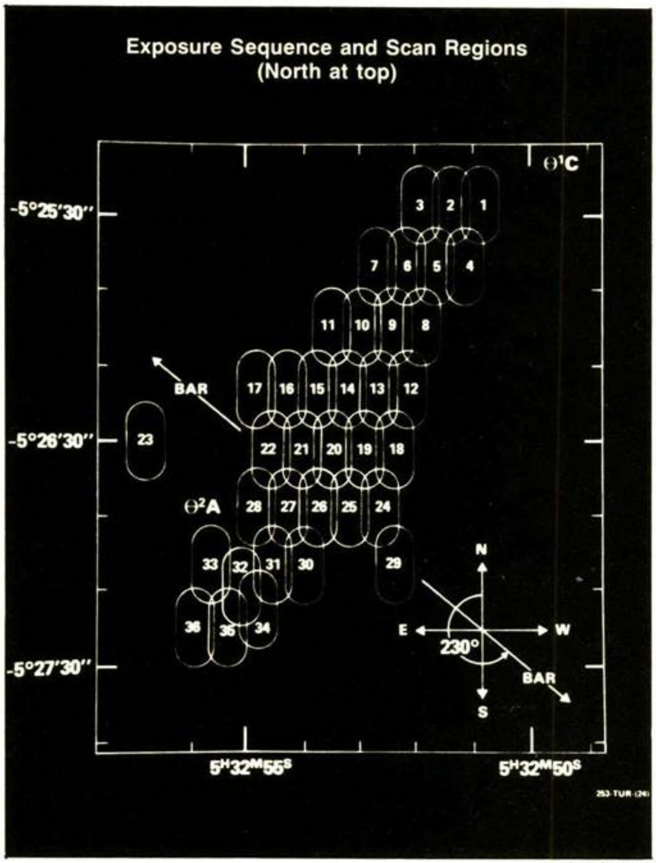


authors' photo

The center is modeled after the control room of a large ground-based telescope: you sit in a warm lighted "data room" while the telescope operates in the cold and dark. In this case, the telescope is simply a little farther away — 20,000 miles instead of 75 feet! Otherwise, observing with the IUE is remarkably similar to using any ground-based telescope. The key element is "real time" operation, which means the instrument responds to commands from the ground essentially immediately, so the observer can view the data and make decisions as events unfold. For an IUE observer, everything happens "now."

Nearly all satellite observatories operate in a stored-command, delayed-response mode. This means planning and pre-recording your instructions to tell the satellite what to do during your run, and typically involves a delay of a day or more. The difference between real-time and delayed-action operation is like live versus videotaped television. The delayed-action mode, necessary for satellites not in continuous contact with ground stations (as IUE is), can be severely limiting. But with the IUE, the flexibility of catching a fast-breaking event as it occurs and being able to follow up immediately is responsible for much of the satellite's scientific success and the excitement many observers feel when using it.

In the telescope control center, you sit before a color television monitor, part of the IUE experiment display system. The monitor shows what the telescope is seeing



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— either a finder-field image used to fine-point the telescope or an image of the actual ultraviolet spectrum being observed. In either case, you are seeing a digital image — one which conveys its information in a multitude of individual picture elements called pixels.

Every IUE image comprises nearly half a million pixels arranged in 768 rows of 768 pixels each. A pixel's response to the light falling on it is divided into 256 brightness steps and assigned a number from 0 to 255. The on-board electronics sample the brightness of each pixel at the end of the exposure and radio the information back to Earth. There a computer takes the incoming signal (giving pixel location and perceived brightness) and reconstructs the signal on the screen of the monitor in the control room. Viewed this way, the individual pixels of an IUE image blend together much like the halftone dots in a newspaper photograph; an entire IUE spectrum on the television screen looks like a spectrum on an ordinary photographic plate. But if you want to examine the image in more detail, you can ask the computer to zoom in and enlarge any given section — although you'll never see anything smaller than one pixel across.

Visitors to the National Air and Space Museum in Washington, D.C. can stand in an observer's shoes at the IUE display in the Stars exhibit. An actual IUE display console (a retired backup model) is set up beneath an engineering mockup of the IUE spacecraft suspended from the ceiling. You can select one of four objects to "observe"; the console displays a series of videotape loops, representing what an IUE astronomer might see during a real observing run.

During our Orion Nebula observations, we sat beside a telescope operator who ran the display console and sent operating commands up to the satellite. To save time and minimize the chances for error, only trained staff are allowed to operate the console. To the right of the telescope operator sits the resident astronomer. IUE resident astronomers are scientists who supervise the telescope operations control center, work with the telescope operators, and assist visiting observers in planning and carrying out their observations and interpreting the results. Apart from their control center duties, the resident astronomers also plan the overall scheduling of observing programs and are responsible for calibrating and monitoring the performance of IUE's instruments.

Our observing program involved taking an overlapping series of spectra across the central region of the Orion Nebula. To do this, we asked that the telescope be aimed by offsetting from the bright star θ^2 C Orionis. (We had previously calculated the extent and direction of the offsets.) These offsets were written down on the observatory record form, nicknamed the "observing script," which also specifies the desired instrument parameters, such as exposure duration, for each image. A resident astronomer worked with us to ensure the offsetting went correctly and efficiently.

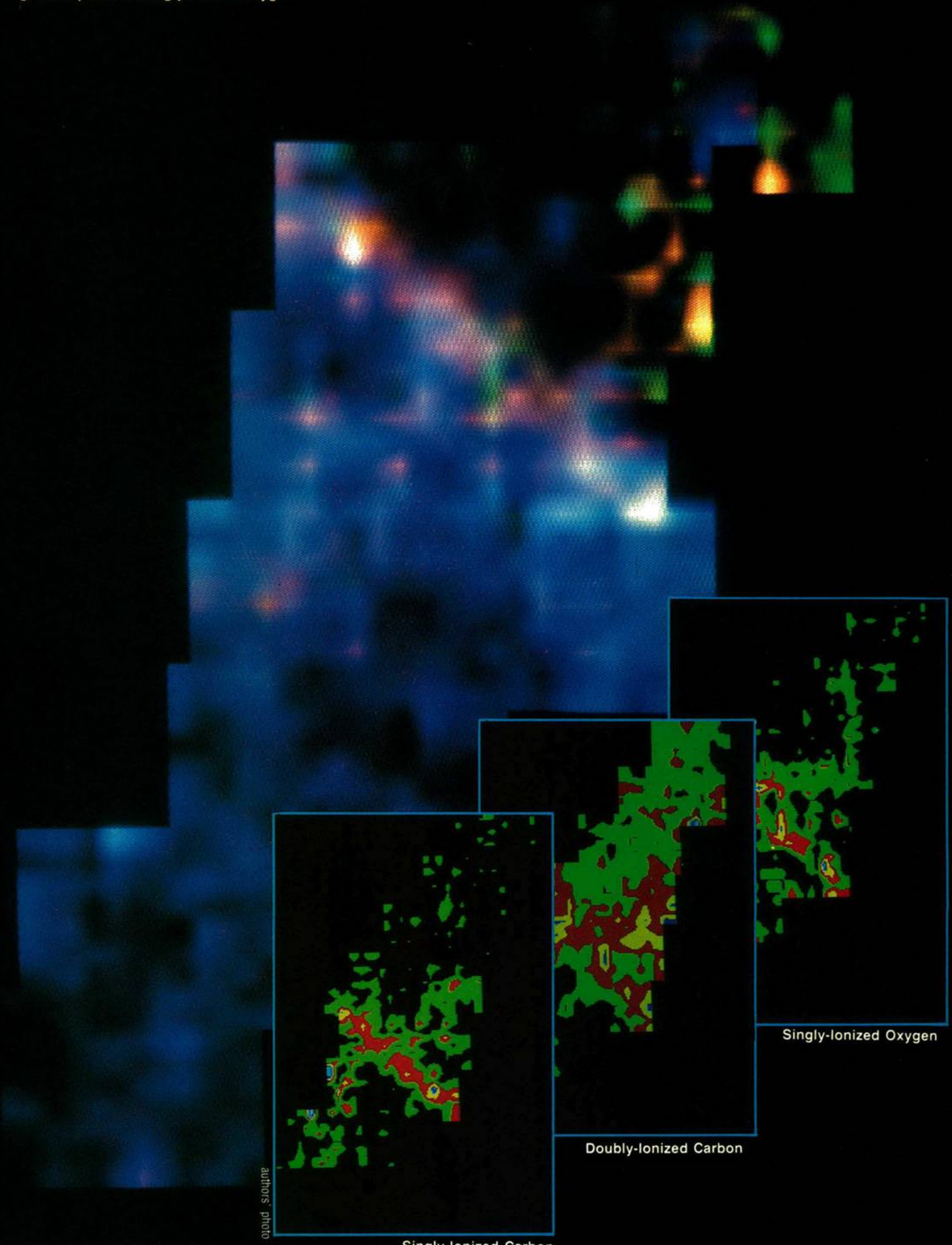
As we obtained the spectrum at each location within the nebula (exposures typically ran 5 to 10 minutes each), the console screen displayed it with the pixel intensity levels coded in arbitrary colors. Examining the spectra briefly, we took preliminary notes in our observing log book, which also recorded the telescope pointing offsets and contained a master grid map of the overall region with the areas to be studied marked out. As the data poured in and took shape on the screen, we decided the sequence and nature of our next observations. Thanks to the efficiency of the telescope operators and resident astronomers, we got spectra of 35 adjoining areas in the center of the Orion Nebula.

Once an observer has viewed the raw television images, the IUE image processing staff takes over. They run the raw images through a series of complicated reduction steps in a computer. According to the instrument configuration and the observer's instructions, the image processing specialist selects the proper steps to process the data. The processing algorithms manipulate the digital pixel values to remove so-called instrumental signatures — wavelength-dependent sensitivities, nonuniformities, nonlinearities, geometric distortions, and so on — from the raw data and return astronomically-useful results (known generically as "data products") to the observer for analysis. Processing a raw image takes approximately 30 to 45 minutes, depending on whether the observer has a low or high-resolution image. The data products can include magnetic tapes, paper plots of spectral flux as a function of wavelength, and even photographs (the computer can make 8x10-inch transparencies).

After an observer's mass of data has been reduced, it goes to the data management center located just down the hall from the control rooms. The data management center logs in, accounts for, and distributes each IUE data product. All the scientific and technical expertise required to operate the IUE satellite is directed toward a single goal: putting the data into the hands of the observer, its "rightful owner." For the first six months, the original observer has exclusive use of his data. After that, it is made available to any qualified scientist through the National Space Science Data Center at Goddard and other data centers in Europe.

Also in Building 21 with the control center is IUE's

Background: A false-color composite of IUE images. Singly-ionized carbon shows red, doubly-ionized carbon is blue, and green represents singly-ionized oxygen.



Singly-Ionized Oxygen

Doubly-Ionized Carbon

Singly-Ionized Carbon

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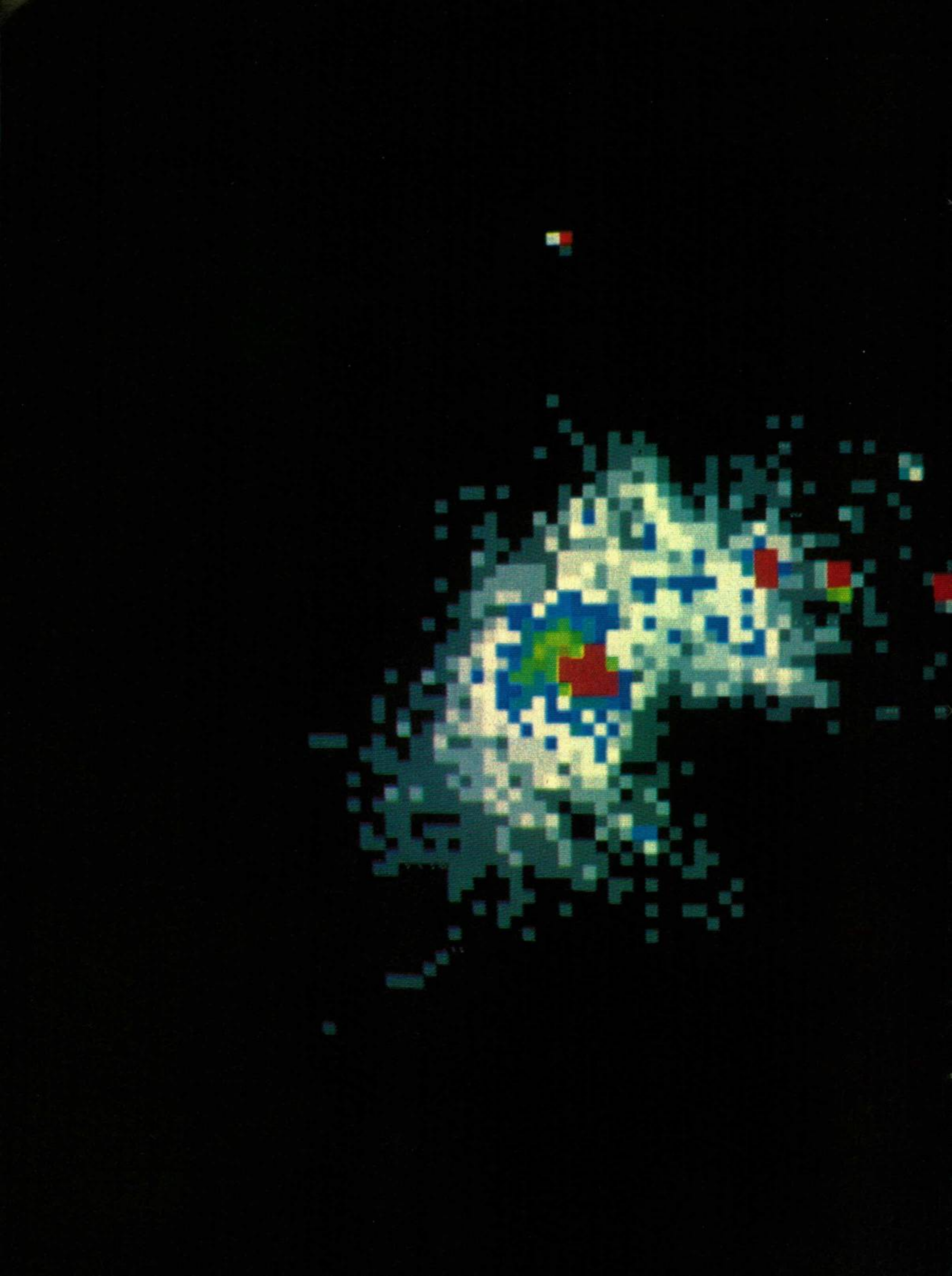
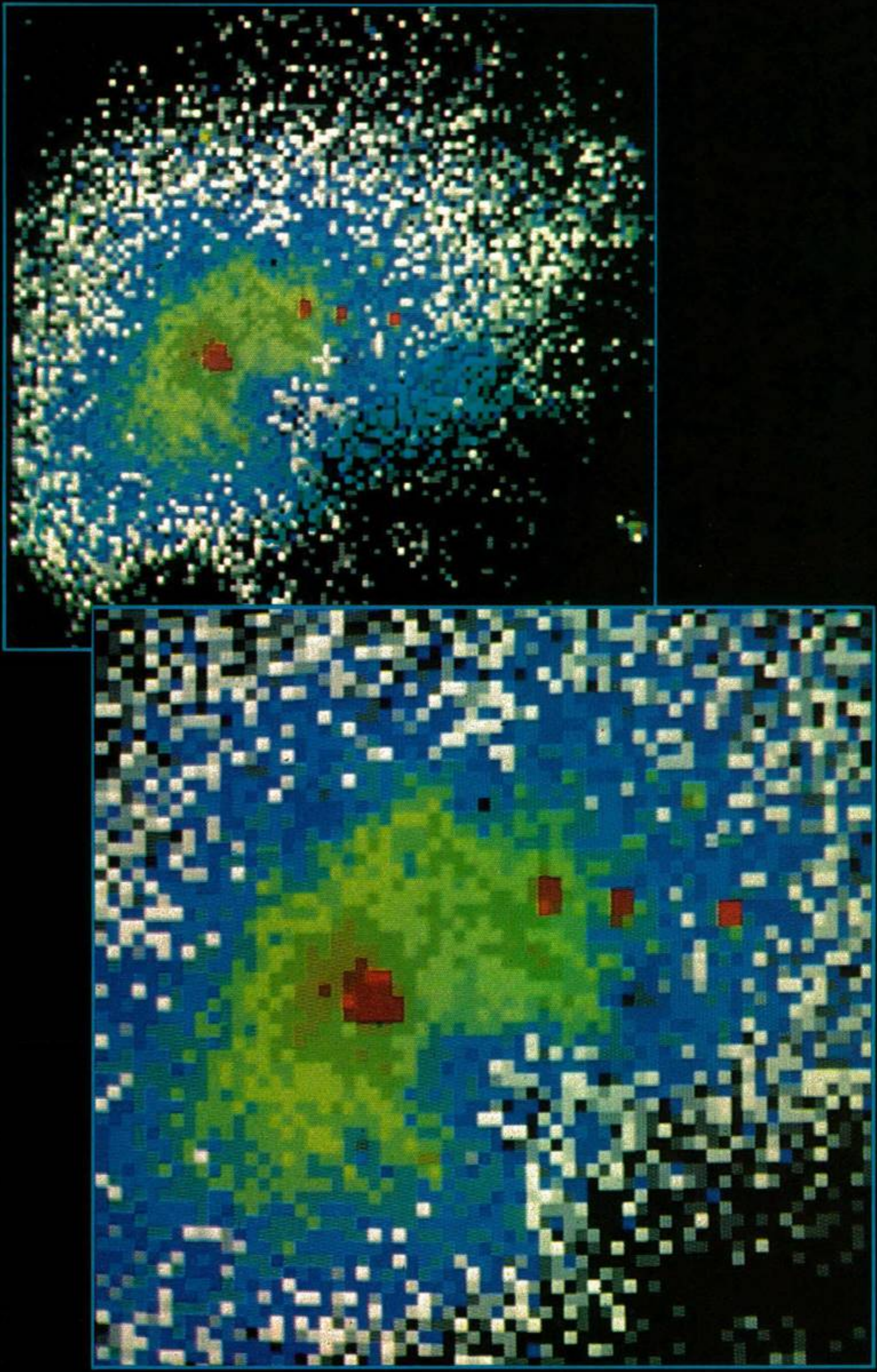
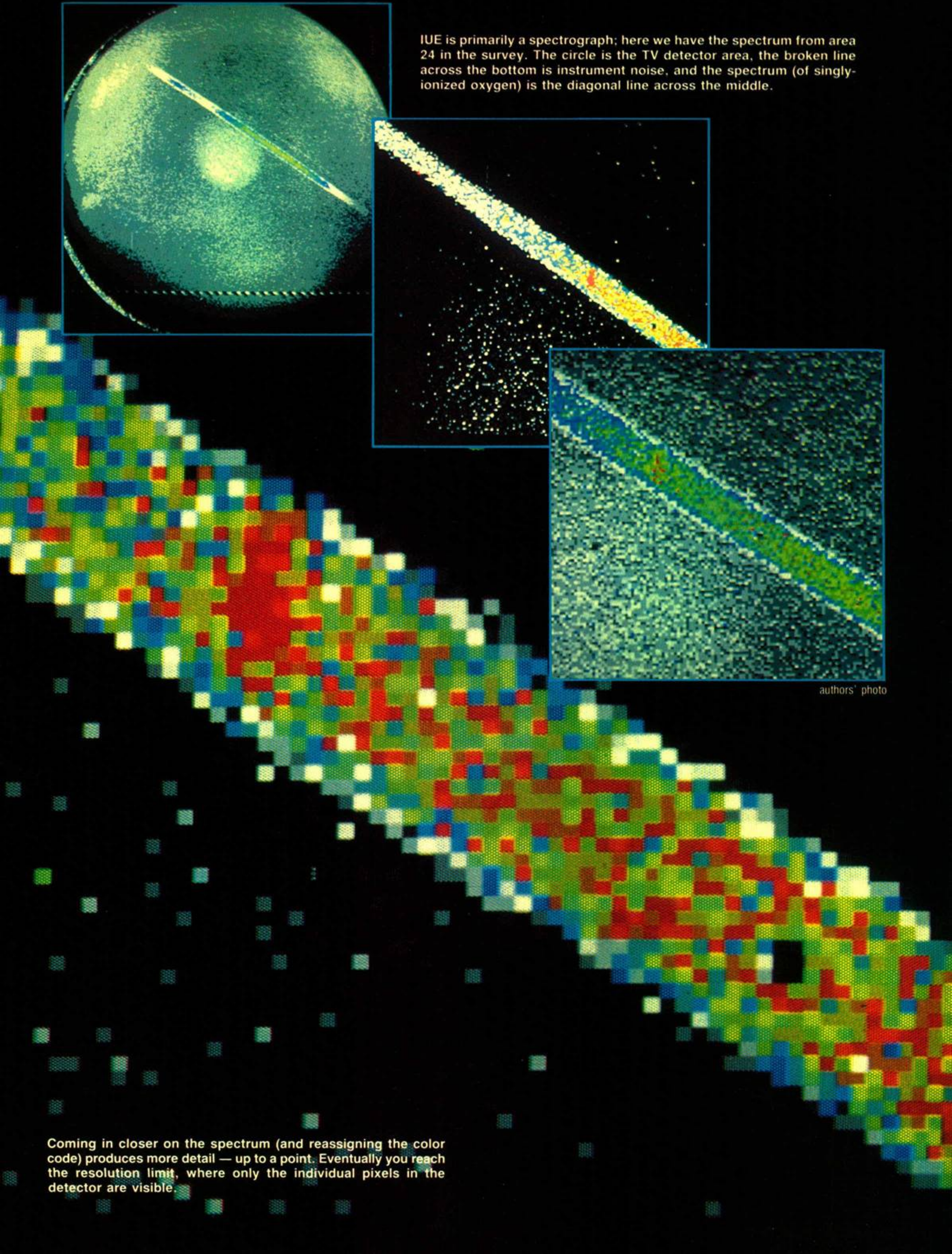




Above: IUE's Fine Error Sensor acts as the satellite observatory's finderscope. Here we see a false-color image of the Orion Nebula's central region in blue light. The overall shape resembles its appearance in a backyard telescope; the Trapezium is the large red blotch in the center.

Moving in — first the "wide-field" image, then a closer view. Finally, after zooming in, the authors adjusted the brightness scale to darken the background (left).



IUE is primarily a spectrograph; here we have the spectrum from area 24 in the survey. The circle is the TV detector area, the broken line across the bottom is instrument noise, and the spectrum (of singly-ionized oxygen) is the diagonal line across the middle.

authors' photo

Coming in closer on the spectrum (and reassigning the color code) produces more detail — up to a point. Eventually you reach the resolution limit, where only the individual pixels in the detector are visible.

regional data analysis facility. This facility was established in 1980 to provide centralized data analysis for IUE observers. Working with the magnetic tapes of reduced spectra, observers can use a large computer and peripherals for astronomical analysis to measure spectral line strengths, positions, profiles, fit theoretical models to observed flux distributions, and so on. A resident manager, a resident scientist, and two resident analysis assistants work with the visiting scientists. IUE also funds a similar facility at the University of Colorado for astronomers in the western half of the United States.

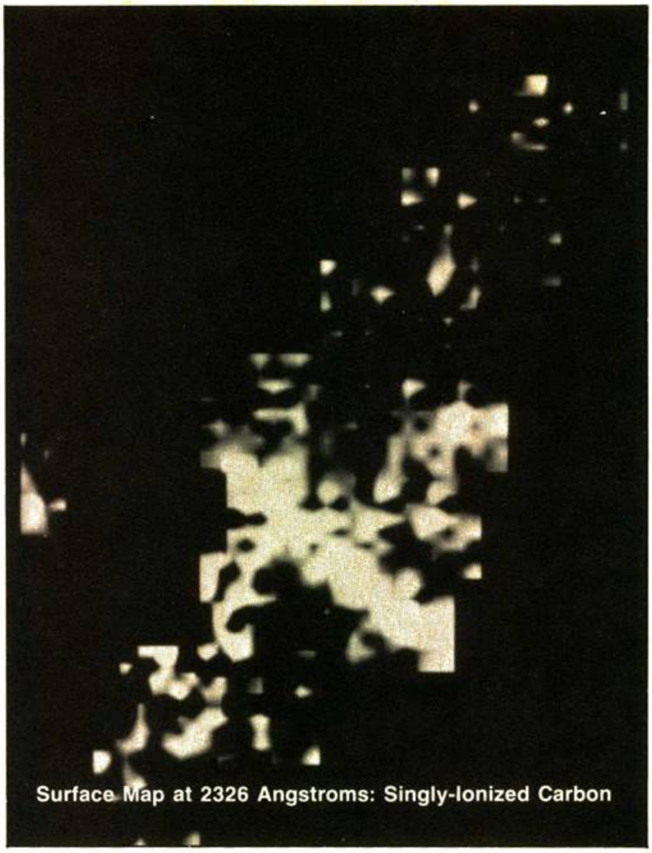
For our Orion Nebula mapping analysis, we started with the basic data tapes generated by the standard processing. We and our collaborators (Christopher Harvel, Randall Thompson, and Anthony Mallama) then computer extracted images of small portions of the nebula, one region at a time. Each showed how much ultraviolet light was coming from the ionized gas in different parts of the nebula at each of the special wavelengths we'd selected. The regions formed an overlapping grid of points when placed together and the result was a mosaic image of the nebula. We call such images monochromatic because we use the light of only a single wavelength, or color, to form the image.

In our program, we were working at three distinct wavelengths: 1909 A (representing emission from doubly-ionized carbon atoms), 2326 A (representing emission from singly-ionized carbon atoms), and 2470 A (representing emission from singly-ionized oxygen atoms). We'll explain a little later why these wavelengths were chosen.

When information is displayed graphically, the human brain is rather good at picking out patterns. Relationships that are completely invisible when presented in raw numbers become overwhelmingly obvious when displayed pictorially. To make the job of comprehension easier, we directed our computer to make a composite image of the three-color Orion Nebula data: each monochromatic image was artificially color-coded and then combined with the other two. Such displays show the data compactly while highlighting the differences between the constituent monochromatic images. We coded the 1909 A image as blue; the 2326 A and 2470 A images were coded as red and green, respectively. You can see the result on pages 12-13.

In our program of mapping ultraviolet emission from selected regions of the Orion Nebula, we were looking at the distribution — the structure — of ionized carbon and oxygen throughout the inner nebula. The composite image shows a whitish linear feature oriented diagonally. The feature appears white because it shows up about equally strongly in all three colors; it corresponds to the well-known filamentary bar seen and photographed at optical wavelengths. This bar is an ionization front — a boundary between the ionized gas near the hot Trapezium stars and the un-ionized gas farther away.

If you look at the surface brightness of the bar in detail, you discover it is different for the carbon emission than for the oxygen emission. In addition, the emission from the doubly-ionized carbon spreads throughout the region from the bar toward the Trapezium, whereas the emission from the singly-ionized carbon and singly-ionized oxygen concentrates near the ionization front. Beyond the bar, little doubly-ionized carbon appears, although some singly-ionized carbon and oxygen emission is present, most noticeably in several low-excitation "cloudlets" — compact regions of emission charted previously by others in the optical spectral region. We saw essentially no doubly-ionized carbon ultraviolet emission in these cloudlets in our low dispersion study.



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By themselves such data are of small interest, but if we can derive the density and temperature of the gas, we can then determine how much carbon and oxygen are present. *That* takes us into the realm of building models — a much more exciting prospect. We're working on this, but unfortunately, we can't just reach out and sample a chunk of nebula. The problem is compounded because we're unable to observe the nebula from any other viewpoint. Moreover, in such a richly-complex structure local differences in density and temperature are extremely important, but difficult to assess at long distance: the easy-to-make "global" measurements lump together too large a region of space to be of much help. It's a bit like determining that the average elevation of the Earth's surface is a mile and a half below sea level — you may have a useful number, but it's the exceptions that make all the difference!

We hope you've gotten a feel for how a modern space-borne telescope can add to our knowledge of the Orion Nebula. We've focused on only a small part of IUE's research, and have presented a rather personal view from the perspective of more than seven years' experience as part of the IUE observatory staff. Today, the IUE continues to sweep around the Earth, scanning the heavens and returning first-rate scientific data. With luck, it will remain one of astronomy's most useful tools for years to come.

Peter Perry and Barry Turnrose are astrophysicists with the System Sciences division of the Computer Sciences Corporation in Silver Spring, Maryland. Both have worked with IUE since before launch, and have interest and experience in the astronomical applications of digital image processing.

Astronomical Ballooning

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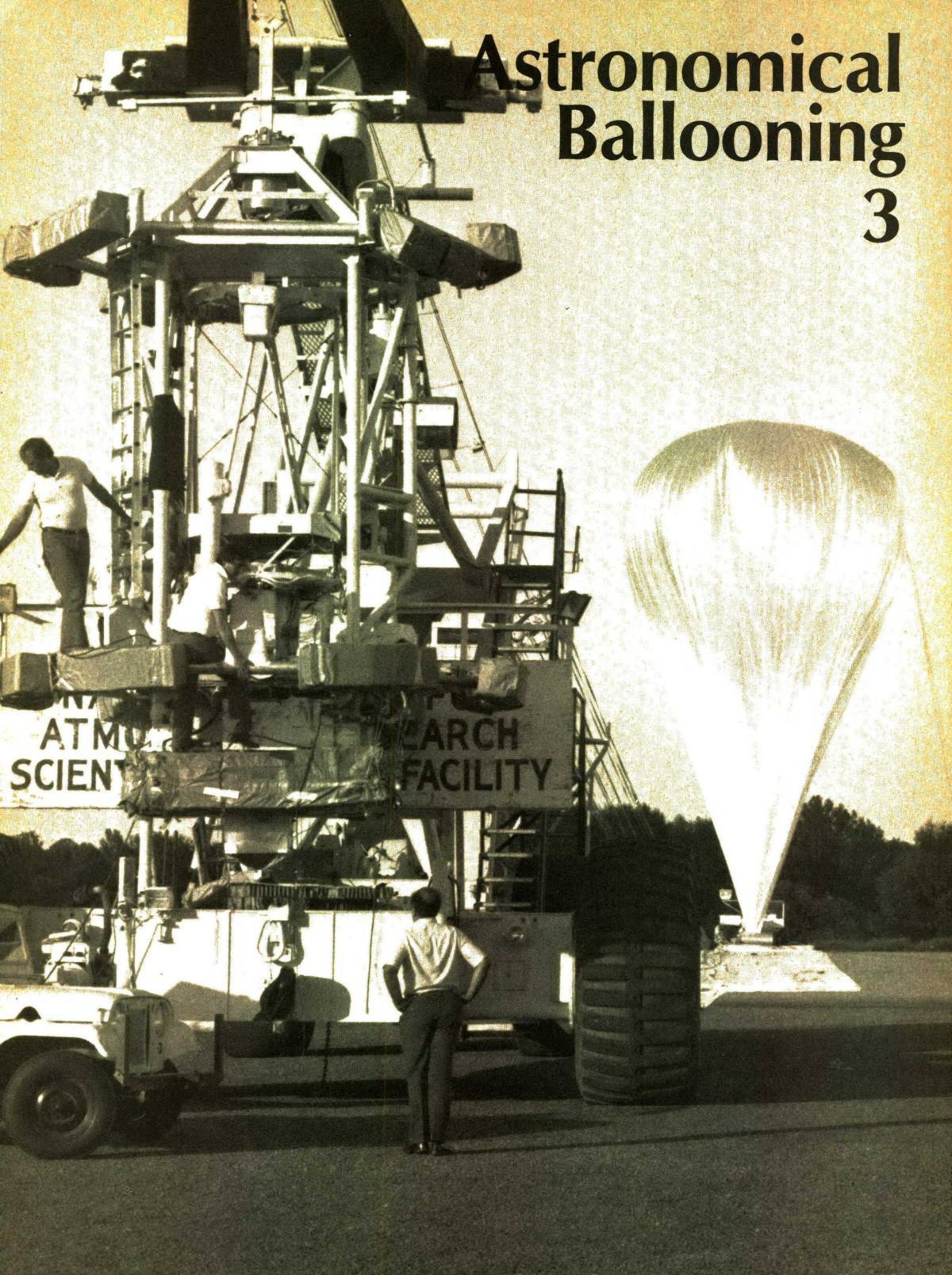
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As a young amateur astronomer, I used to wonder how professionals knew so much about what was happening thousands of light-years away. I remember poring through the popular journals to keep up to date on recent discoveries. But reading those articles was a bit like watching the spinning crankshaft of a car — you could tell a lot was going on, but just how it made the thing run remained a mystery.

Years later (by then a professional astronomer myself), I realized that there's nothing especially mysterious about this process. After all, we expect artists and musicians to experience da Vinci's paintings and Bach's cantatas in a deeper, more abstract way than novices. In an analogous way, when astronomers contemplate the universe, they take the simple perceptions provided by their instruments and refine them to where the subtleties of how things work can be discerned more easily. Astronomers seek out the hidden relationships that underlie apparently unrelated things — relationships that lie at the heart of the natural world.

The Road to Discovery

by Sten Odenwald

We've already seen how infrared astronomers gather their data ("Astronomical Ballooning," August 1984) and how they analyze it to make maps of particular objects in the sky ("A Quickie Guide to Analyzing Balloon Data," February 1985). Now I'd like to show some of the behind-the-scenes thinking that goes along with transforming a calibrated infrared map into a quantitative statement about a particular astronomical object. To focus our discussion, let's look at the center of our Galaxy — a region of considerable mystery and excitement.

During the last 50 years, several hundred astronomers have written more than 550 papers on the galactic center. Like a guild of painters laboring on a single giant canvas, some astronomers use data to paint bold aggressive swatches of color while others fill in details. Out of this activity — honed by discussion, argument, and theorizing in technical journals — astronomers have created an intriguing picture of what lurks in the Milky Way's core. This undertaking is even more impressive when you consider that the galactic center itself is completely hidden from view by 10,000 parsecs of intervening dust and gas. Only radio, infrared, and some X-ray and gamma-ray radiation succeeds in penetrating the murky veil.

Within 800 parsecs of the galactic core, radio astronomers have detected weak signals from molecular hydrogen and carbon monoxide which suggest a rapidly rotating disk of hydrogen gas inclined to the galactic plane by about 24 degrees. No one knows why the disk tilts, but it might relate to tidal torques between this region and the rest of the Galaxy's disk or gravitational perturbations from the Magellanic Clouds, the Milky Way's small satellite galaxies.

Closer still, within 250 parsecs of the core, molecular clouds can be detected that superficially resemble those observed in the spiral arms of the Milky Way. Thomas Bania of Boston University estimates the total amount of molecular hydrogen in these clouds may mass as much as 350 million Suns. In 1972, mathematical models by Nick Scoville at Columbia University suggested that the bulk of the molecular clouds form a giant ring 250 parsecs in radius and expanding at about 50 kilometers per second. The discovery of outwardly-expanding clouds from the galactic core led many astronomers to speculate that the "molecular ring" was ejected in a titanic explosion in the Milky Way's core millions of years ago.

To complement the molecular picture, radio astronomers have shown that the entire region — extending hundreds of parsecs outward from the core — is suffused with hot ionized hydrogen gas. Some of this gas takes the form of clumps that look suspiciously like ordinary HII regions, such as the Lagoon Nebula in Sagittarius or the Great Nebula in Orion. This is unexpected since HII regions normally reside in the spiral arms of the Milky Way. Moreover, all HII regions are young and contain massive O or B-type stars that burn their nuclear fuel at a furious pace. Finding HII regions in or near the galactic core raises questions of where they came from — and what keeps generating them.

The galactic center also contains other objects whose nature remains stubbornly enigmatic. For example, two years ago F. Yusef-Zadeh, Mark Morris, and Don Chance at Columbia and UCLA used the Very Large Array radio telescope to map the galactic center. They discovered enormous filaments above and below the molecular ring and extending nearly 100 parsecs. These filaments suggest the galactic center contains an enormous magnetic field that controls the flow of gas over at least this distance. But where does it come from?

Tantalizing glimpses of the galactic core have also been provided by astronomers Robert Brown, Ken Johnston, and Ronald Ekers. In 1983, they may have observed spiral-shaped streamers of ionized matter falling into — something. But what? A black hole?

Moving still deeper into the core, the inner few parsecs are surrounded by a dusty ring according to infrared astronomers Eric Becklin, Mike Werner, and Ian Gatley. Inside this dust ring lie dozens of clouds, discovered by John Lacy and his coworkers. Each cloud has about the mass of the Sun and seems to be expanding at 100 kilometers per second. These clouds don't appear to have the basic properties normally associated with planetary nebulae or HII regions. What are they?

Over the last 10 years, gamma-ray astronomers have discovered in the galactic core a powerful source of radiation — the kind produced when electrons and positrons annihilate one another. Theoretical models suggest this source is less than about 2100 kilometers across. Is this, finally, the fingerprint of the true core — a 1000-solar-mass black hole?

It's abundantly clear that the galactic center is a dynamic, energetic place unlike any other similarly-sized location in our Galaxy. Now what can we, using our infrared map, contribute toward a better understanding of this strange region? Let's see if the map can answer the basic question of what makes the galactic center such a powerful source of infrared radiation.

At sunset, the crew readies the balloon and its infrared telescope cargo for another all-night flight into the stratosphere. Photo by the author.

Our map shows two kinds of emission at far-infrared wavelengths: a smooth component extending a radius of about 200 parsecs along the galactic plane and 30 parsecs above and below it. There is also a clumpy component which occupies the same region along the plane but spreads more narrowly above and below. Treating the individual clumps as independent sources, we find several cases of a source lying adjacent to a nebula visible at optical wavelengths. Since we know that dust in the galactic plane prevents light from traveling more than a few thousand parsecs, to be seen these sources almost certainly lie nearby and must be unrelated to the galactic center. We'll declare them foreground objects and ignore them. They're irrelevant to our present analysis, but may be useful later in some other avenue of research.

This leaves us with the clumpy sources which lack optical counterparts. Let's assume for now these sources are all at the same distance as the galactic center. Since we know about how far that is, we can correlate the detected amount of infrared emission with the distance to derive a real luminosity for each source. But our estimated luminosity for each source contains several uncertainties. First, we know the distance to the galactic center only approximately: it is 10,000 parsecs, give or take 500. Second, our instruments measure infrared brightness to an accuracy of only 20 percent or so. Keeping these and other uncertainties in mind, we plug our best estimates into the computer and turn the crank. We discover, to our surprise, that the far-infrared sources shine with luminosities between 140,000 and 81,000,000 times that of the Sun! The *puniest* of these sources has roughly the same output as the Great Nebula in Orion!

Comparing our far-infrared map with the 1978 radio map made by Dennis Downes and his coworkers at Bonn reveals another important fact: the radio and infrared maps are strikingly similar. The far-infrared and radio signals seem to come from the same parts of the sky with about the same relative brightness and the same overall size and structure. This suggests that whatever these sources might be, they seem to produce both kinds of radiation at the same time. But what are they? Well, there are many physical processes that can produce both radio and far-infrared emission. Astronomers observe a number of these at work in other parts of the Milky Way. The most common mechanism seems to involve very hot and luminous stars between spectral classes O and B. These stars are capable of producing large quantities of radiation powerful enough to ionize the surrounding hydrogen gas and heat the nearby dust.

Now that we suspect O or B-type stars are involved along with dust and gas in each of the sources, we use these ingredients to build a detailed mathematical model. This will predict just how much radio and far-infrared emission we should expect to see if a young luminous star were embedded in a dense cloud of dust and gas.

This model, like all others astronomers use, is based on a specific set of physical principles or laws which we think are relevant to the data we're trying to understand. Mathematical models of HII regions, for example, show that the energy from the star can be converted into radio and far-infrared emission as its radiation streams into the surrounding cloud of gas and dust. For the objects we see in the galactic center, these models predict that each source could be dominated by a small cluster containing 1 to 5 very hot and massive stars between spectral classes O4 and O8. The precise numbers are somewhat ambiguous and if less-luminous O-stars are also present, there could be as many as 50 to 100. The models also predict that each source contains about as much gas and dust as that in typical HII regions found elsewhere in the Milky Way.

All right so far. At least in their gross physical properties, the objects that appear in the map do not represent any revolutionary new species of astronomical object. We can also conclude from the model that massive O-type stars must have formed in the heart of our Galaxy during the last few million years, since that's how long other mathematical models tell us it takes for such stars to be born.

I mentioned before that there seemed to be two components to the galactic center's far-infrared and radio emission. If the clumpy component represents young star-forming regions, what makes up the smooth and extended component? So far, the clumpy component accounts for only about 15 percent of the total infrared luminosity from the galactic core — where's the rest coming from? One simple model suggests that 30,000 to 50,000 B0-type stars (hot, but a little cooler than the O-type) could give us something that looks at least superficially like the extended component, providing the stars were embedded in a uniform interstellar medium containing the normal amount of dust.

These type B stars would be too numerous and faint for us to see individually with our balloon-borne instruments — all we would observe is their combined unresolved emission. A search through some of the papers published on the galactic center reveals that large populations of B stars in the galactic center — though not quite so numerous as what we're thinking of — were proposed by Luis Rodriguez and Eric Chaisson of Harvard University back in 1978. This is encouraging since it means that other astronomers, using entirely different kinds of data, have already come to a similar conclusion.

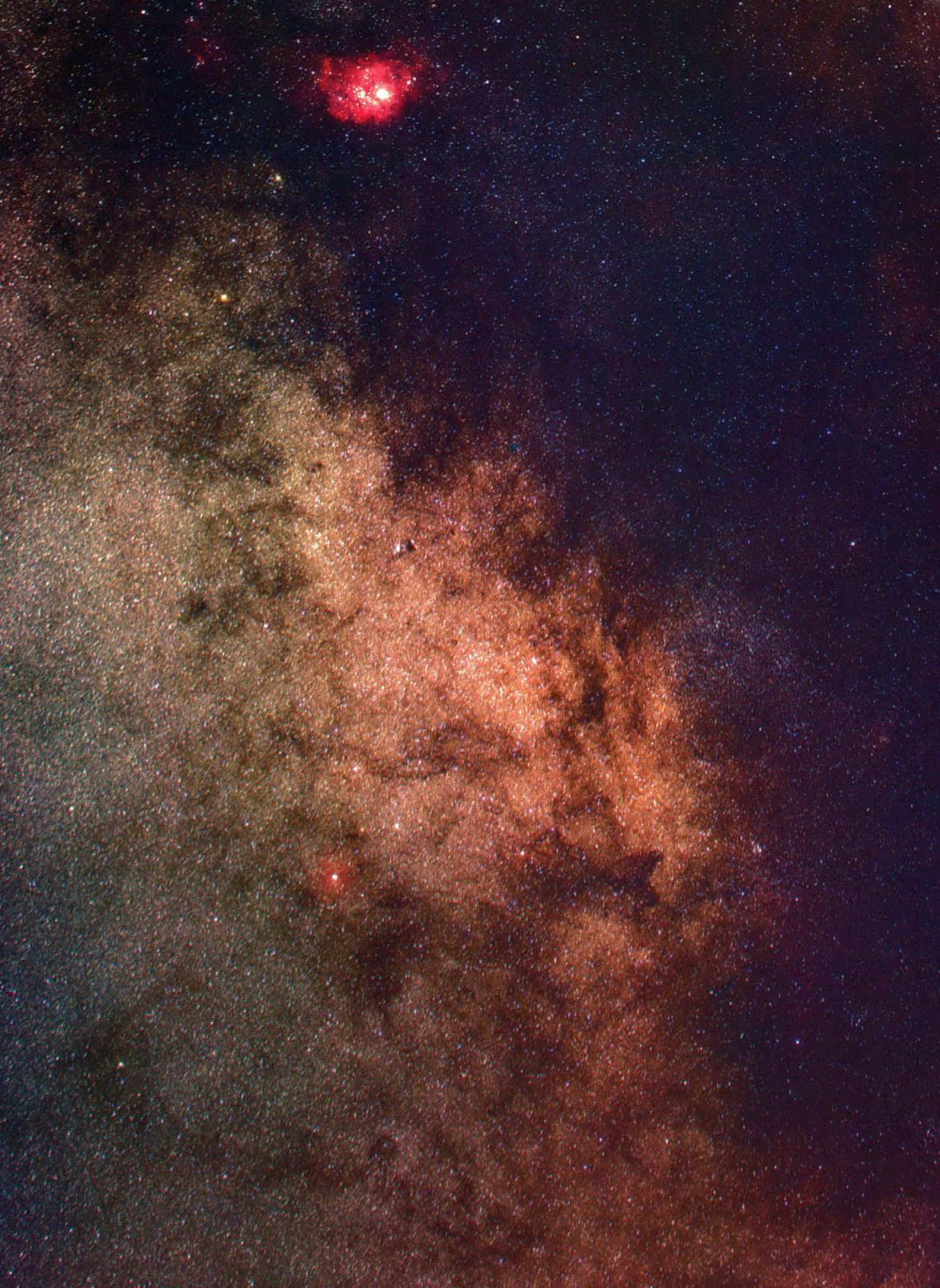
The radio and far-infrared data leave us with an interesting problem: How do we explain the mutual existence of up to 800 O-type stars in the clumpy sources and tens of thousands of B-type stars in the extended emission region? The problem stems from an observed fact of stellar "demographics" — if O and B-type stars are born in the galactic center with the same relative frequency as those in the rest of the Galaxy, having 30,000 B0 stars implies we ought to have about 160,000 O-type stars also present. But this is about 200 times too many O stars, according to our radio and infrared data. We need a plausible explanation that gets rid of at least 99 out of every 100 type O stars born in the galactic center.

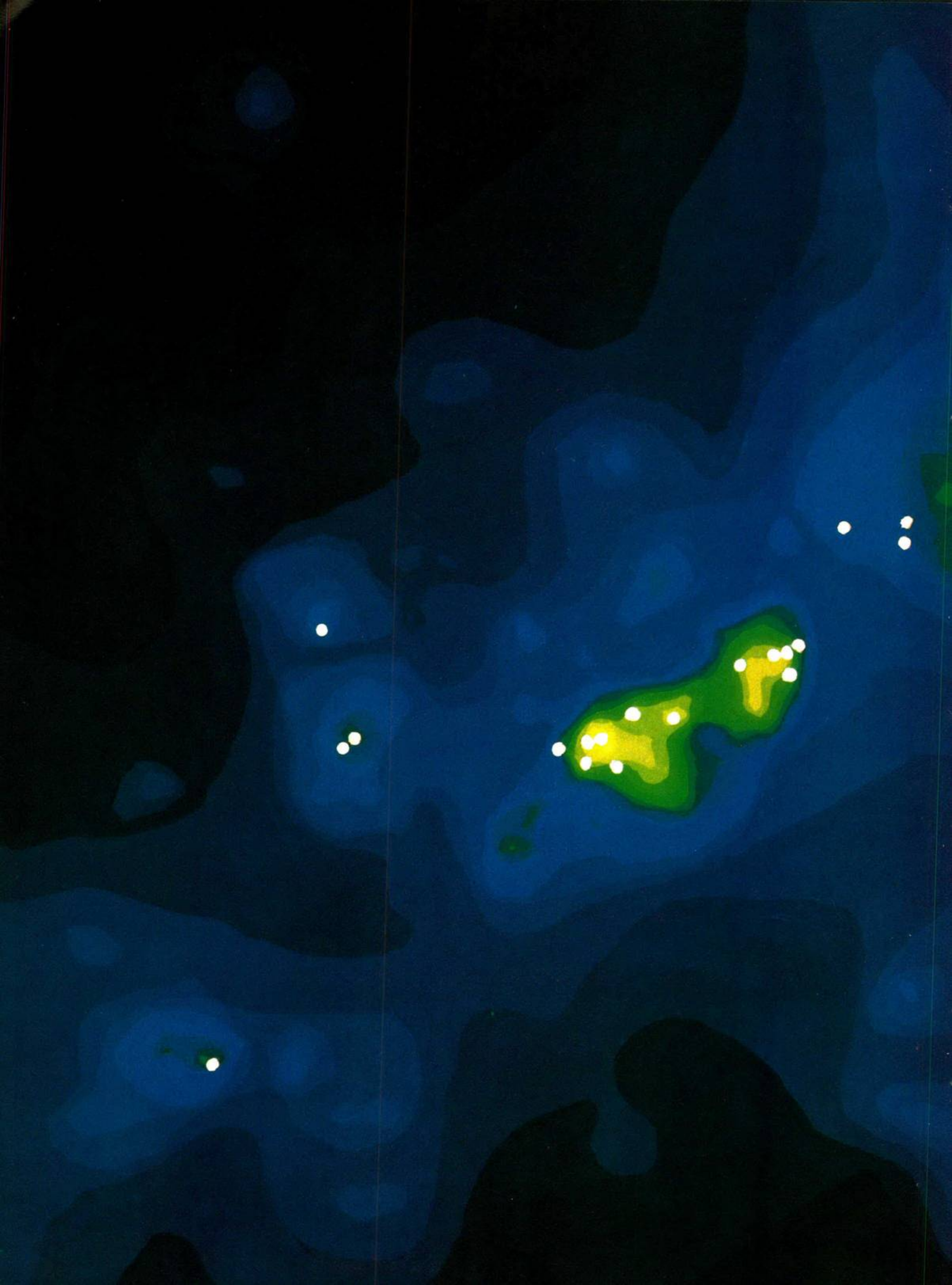
There are many possibilities, but the best candidates are:

1) In the last 10 million years, most of the O-type stars evolved into red supergiants, neutron stars, or even black holes, leaving only a few stragglers to account for the ones now observed.

2) For some unknown reason, O-type stars form less frequently in the galactic center than elsewhere in the Galaxy. If only one O star formed in the galactic center for every 200 B0 stars (rather than the 1-for-5 ratio in the

Thick clouds of stars, ruddy nebulae, and dark alleys of dust: the Milky Way in Sagittarius. Thirty thousand light-years into this picture lies the heart of our Galaxy — a mysterious region so distant and dust-enshrouded that only infrared and radio waves can pierce the murky veil. Photo by Ronald Royer.





The galactic center and neighboring regions of star-formation as seen in the far infrared. Maps such as these show only the energy coming from this part of the sky — understanding what kinds of objects produce the energy involves many assumptions, some guesswork, and endless testing and retesting of mathematical models based on astrophysical theories. Map by Thomas L. Hunt after data provided by the author.

authors' photo

rest of the Galaxy), the proportion would come out about right.

3) Our estimates for the number of B stars are too high by a factor of 40, and the extended far-infrared emission is due to a large population of old stars. The radio emission we see would then come from old supernova remnants, not young type B stars.

At this point, perhaps we can glimpse part of an explanation. Our mathematical model for the Sagittarius A source (the core of the Milky Way) predicts that a cluster of about ten O4 stars would yield the observed radio and infrared emission. Such a source would have an effective temperature equivalent to that of a typical O4 star, about 50,000 Kelvins.

Against this, however, is the evidence of astronomers who study the abundances of certain ionized species of atoms. They tell us that the radiation field around the galactic core cannot have a temperature greater than about 37,000 K. Only stars with spectral classes cooler than O8 satisfy this constraint. This means our original mathematical model (with ten O4 stars) is invalid, but if we substitute into it approximately 150 O8 stars — individually cooler and less luminous — our predictions match the available data much better. (Of course, this leaves a thorny problem for theorists — devising a star-formation mechanism that systematically eliminates the hotter O-type stars — but a solution here might substantiate the second proposal in the list.)

If this solution sounds a little too patly contrived, the impression may be more apparent than real. At this stage, we know so little about the galactic core that one or more of these possibilities could be made to fit the data we have. Postulating a larger number of cooler O stars for a few hotter ones is perfectly valid and doesn't conflict seriously with established astrophysics. In any case, nobody takes the conclusion as final — future studies, or a more critical evaluation of existing data, will help us decide which way to go next.

In the last 50 years, hundreds of astronomers worldwide have turned their instruments toward the galactic center. Although we'll never visit this mysterious enigma, by examining it from a distance we have learned a great deal about the stellar furnaces that illuminate it, the molecular clouds that inhabit it, and the strange objects that lurk in its murky depths.

There's no real end to this road to discovery. As our data get better, so do our questions. Their answers help refine our physical models and open the way for new insights. Barred from visiting the galactic center, these models provide us with our only means of exploring the region "firsthand."

Our little exercise has reduced the mysterious heart of the Milky Way to an odd collection of numbers. But anyone who sees in this process nothing more than the joyless dissection of Beauty into cold, hard Fact has missed the point profoundly. To paraphrase Oliver Wendell Holmes, astronomy "is painting a picture, not doing a sum." Today we draw only crude sketches of the galactic center — equivalent to the stick figures scrawled by children — but we are working toward the day when we may achieve a da Vincian mastery of detail.

Sten Odenwald is an infrared astronomer at the Naval Research Laboratory in Washington, D.C. His research interests include studying the properties of giant molecular clouds and young star-forming regions of the Galaxy at far-infrared wavelengths.

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ASTRONOMY Forum

The First Time I Saw the Great Omega

Part of the thrill of astronomy is the excitement of discovery — one continually fed by fascinating and inspiring sights. Every time a puff of light representing a far-away galaxy comes through the eyepiece, I experience a twinge of awe, a respect for creation, and oneness with all things. So what if I have to use averted vision to see it. So what if it looks similar to hundreds of others I've viewed. It is a new creation as far as I'm concerned, and I'm privileged to behold it. I can read that a certain galaxy is X number of light-years away, but at the eyepiece my mind transcends time and space — carrying me there to that other world. My observations, therefore, take on a spiritual aspect as well as providing mental and physical exercise.

As an ardent amateur astronomer, my revelations no doubt parallel those of many others. First came knowledge of the general layout of the stars and how different ones can be seen at different times of the year. The stars moved! I never realized they rose and set just like old Sol.

Next came understanding that the apparent motion of the stars followed a prescribed pattern across the sky from east to west. The north star was a pivot point around which all other stars rotated. I was amazed! With the help of library books, I began to tackle the constellations.

It was springtime, so I started with the Great Bear since it was the most conspicuous. I easily made out the Big Dipper and learned about the pointer stars to find *Polaris* and the Little Dipper. If I followed the arc of the Big Dipper's handle, I was told, it would lead me to the bright star Arcturus in the constellation Bootes (which I mispronounced then and probably still do). Continuing along the same arc would bring me to another bright star, Spica, in the constellation Virgo.

I started tying things together and the constellations began to appear just like those laid out on my oversimplified diagrams. I learned about the ecliptic and thrilled to the discovery of Saturn, Mars, and Jupiter. Shortly after, I learned about Jupiter's four bright moons. When I first attempted to glimpse them through a pair of 7x50's, however, they eluded my shaky binoculars. But the fire was lit — I would get whatever was necessary to see those rings.

This meant purchasing a telescope.

> ***But I still didn't know what I'd see through a scope and was hesitant to pay several hundred dollars to find out.***

Any self-respecting astronomer has one and since I knew some of the constellations, could point out four of the planets, and could call several stars by name (including Zubenelgenubi and Zubeneschamali), I figured I was ready for "bigger eyes." There was just one problem: I knew virtually nothing about them. I wrote to practically all of the telescope advertisers in ASTRONOMY and was promptly flooded with reasons why I should buy each particular model.

Although thoroughly confused, I did start to learn the differences between reflectors, refractors, and Schmidt-Cassegrains. I studied the concept of equatorial mounts, motor drives, setting circles, and Dobsonians.

But I still didn't know what I'd see through a scope and was hesitant to pay several hundred dollars to find out. I therefore placed a classified ad in the local paper for a used scope and got one call from a man who was selling a Schmidt-Cassegrain. He graciously invited me over for a "look-see." I had never seen a Schmidt-Cassegrain "live," and was impressed with its construction and appearance. The real excitement came when I looked through the eyepiece and saw Saturn's rings for the first time. From Saturn we went to Jupiter, then Mars, and then back to Saturn. Just those three objects kept us occupied for a couple of hours.

That meeting convinced me of one thing: The scope I bought must have an electric drive. The host did not hook up his drive and used very high-power eyepieces. As a result, objects scooted out of the field of view in just seconds. Not knowing any better, I assumed it would be a constant hassle to keep an object in view without a drive.

Although impressed with the Schmidt-Cassegrain, I decided I could get a Newtonian with basically the same optics for about half the price and finally settled on an 8-inch model complete with equatorial mount, motor drive, setting circles, and viewfinder. No child ever anticipated Christmas more eagerly or more impatiently than did I the arrival of that scope.

The day it came was crystal clear and that night proved just as cooperative with the Moon a little more than half full. After getting everything together and adjusting the latitude angle (which I still wasn't too sure about), I took the rig outside and waited for dark. It was one of those days when the Sun stands still — not wasted time though, since the daylight Moon was a good practice target. My!

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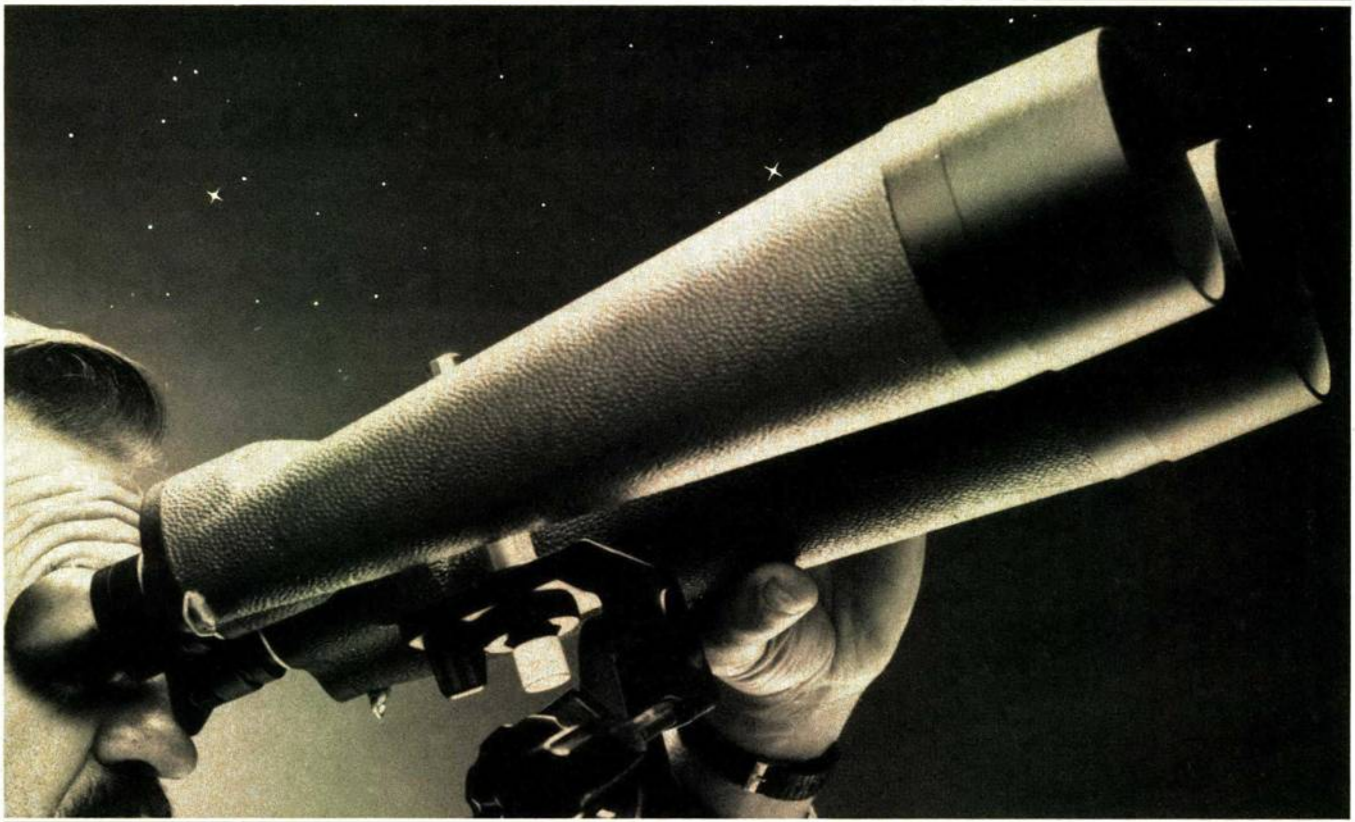

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After everyone left, I had a chance to look through my brand new *Edmund Mag 5* star atlas and was happy to find it much more detailed than the constellation charts I had been using; more importantly, it listed the prominent deep-sky objects. I had learned about galaxies, globulars, open clusters, and nebulae, and had seen many beautiful color photos of these objects. I was particularly impressed with globulars and had scanned Hercules repeatedly with binoculars in search of M-13, but without success. I had no idea exactly where it was or what I would see, but assumed from the spectacular photos that it would just about knock my eyes out as it came into the field of view.

In any event, the little atlas had M-13 plotted — and even gave its distance from Eta Herculis. I located the Keystone and, after fumbling for some time with the unusual movements of right ascension and declination, finally picked up a faint mist of light in my 6x finder. Could that be it? It wasn't very spectacular, but my heart started pounding. I switched down to a 49x eyepiece and jiggled the scope since I didn't have the finder exactly aligned with the field of view. After a couple more jiggles, the cluster appeared in all its glory!

I felt a bit of initial disappointment that the cluster was not as brilliant as the photos and the moonlight washed out contrast, but I resolved outlying stars and could see the great central mass. I ran into the house and brought my wife back out. It was late and she had been getting ready for bed, so I didn't get too many ooh's and aah's over "that little spot of light." I excused her and tried out a higher-powered eyepiece. The huge cluster filled the field and I knew there would be even more glorious sights when the Moon was absent.

In the months to come, I practically wore out the atlas trying to find all the charted objects. My knowledge grew immensely, both of the heavens and about the telescope. I learned that with low-power eyepieces I had no need for an electric drive. Even with higher powers, it was no big deal to swing the scope slightly ahead of the target and let it drift through the field of view.

The *Mag 5 Atlas* served its purpose well, but I eventually found myself having to plot objects that were not on its maps. My plotting was not always very accurate, so I finally ordered the *Mag 6 Atlas* by Edmund which seemed the most logical choice. It opened up a whole new sky full of objects to add to my collection.

About this same time, I developed "aperture fever." After much deliberation and consideration, I ordered a 13-inch Dobsonian. During a three-month wait, my 8-inch scope kept me busy. I had discovered the wonders of *Burnham's Celestial Handbook* — a source of objects that would never be exhausted. There was, however, a problem. The majority of the objects listed by Burnham were not plotted in the *Mag 6 Atlas*. So once again, I did my own plotting, but couldn't write as small or neatly as the printer could print and soon had a hopeless mess. I therefore forked over $30 for Tirion's *Sky Atlas 2000.0* and have never been sorry. The atlas is beautiful, accurate, and a joy to study even away from the telescope.

> ***I had the whole family look — their oooh's and aah's convinced me I had made a wise investment.***

By and by, the Dobsonian arrived and the thrill of adventure was again kindled. I bought an 8x50 right-angle finder and mounted it above the eyepiece holder. It wasn't too difficult getting familiar with the mechanics of equatorial movements, but I found it frustrating trying to find the cardinal movements on an alt-azimuth system. First I set up both scopes and aimed them at a prominent star. Next I swung the 8-inch in right ascension and noted the stars that came into view. Then I tried to duplicate the movement with the 13-incher. It reached the point where I was spending all my time working on the mechanics of observing instead of actually observing.

I finally realized the *Sky Atlas 2000.0* was so detailed that I could star hop easily enough to preclude the need for an equatorial mount. I made a plastic overlay with a circle the same size as the viewfinder's field. By laying this on the chart, I knew exactly what I would see in the finder. Of course, everything was upside-down and reversed from right to left, but those handicaps were eventually overcome. I even learned to approximate the correct movements in right ascension and declination (except in the vicinity of the pole, which still gives me fits).

As I became familiar with the Dobsonian, the 8-incher began to suffer lack of use so I sold it. I built a rolling cart to house all my accessories and miscellaneous items; it converts to a desk at the viewing area and keeps everything compact, readily accessible, and easy to move.

Although there are enough objects in the northern hemisphere to keep me occupied for the rest of my life, I long to see the sights in the far southern sky. The southern charts in *Sky Atlas 2000.0* make my mouth water. One object in particular is especially enticing. I am speaking, of course, of the great globular in Centaurus — NGC-5139 — better known as Omega Centauri. Although theoretically in my range of view, in actuality it's practically an impossibility. I live at 36° north latitude, therefore Omega rises only a few degrees before sinking again. My southern horizon is blocked by a wall of trees and a city (population 50,000) 10 miles distant. The sky glow, of course, is atrocious. The main highway in front of my house runs north-south. As it passes through the wall of trees, a gap is created that gives me a slightly more distant view before other trees again obscure the horizon. At proper times of the year, I have searched the gap for the globular — but to no avail. Once I thought I saw it in binoculars, but wasn't sure. The following night I set up my Dobsonian to align with the gap, but no Omega appeared. I began to think observation at this site was impossible.

Then one day in late April, I spent a wonderful evening exploring the galaxy fields in Virgo and Ursa Major. The night was was very clear, very dark, and relatively still; 13th-magnitude objects showed easily. By 11:30, I was pretty exhausted but hated to leave on such a good night — then I remembered that Omega should be in the gap, or close to it. I took out my binoculars and found Corvus, jumped east to Gamma Hydrae, and then south to Iota Centauri. Since these two stars pretty well point to Omega, I kept moving until they pointed into the gap. I threw up my binoculars and before my eyes was the largest, haziest, most exciting object I've seen as a skywatcher!

There was no doubt about it. I had the great Omega! But the treetops had it too, and in a few minutes they'd claim it again. Moving quickly, I ran back to the scope, took the mirror out, and broke down the tube and base. The cart was set up as a desk and since valuable time would be lost converting it, I put the scope in the back of my pickup truck — then

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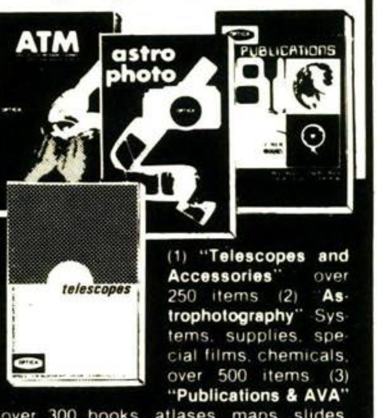

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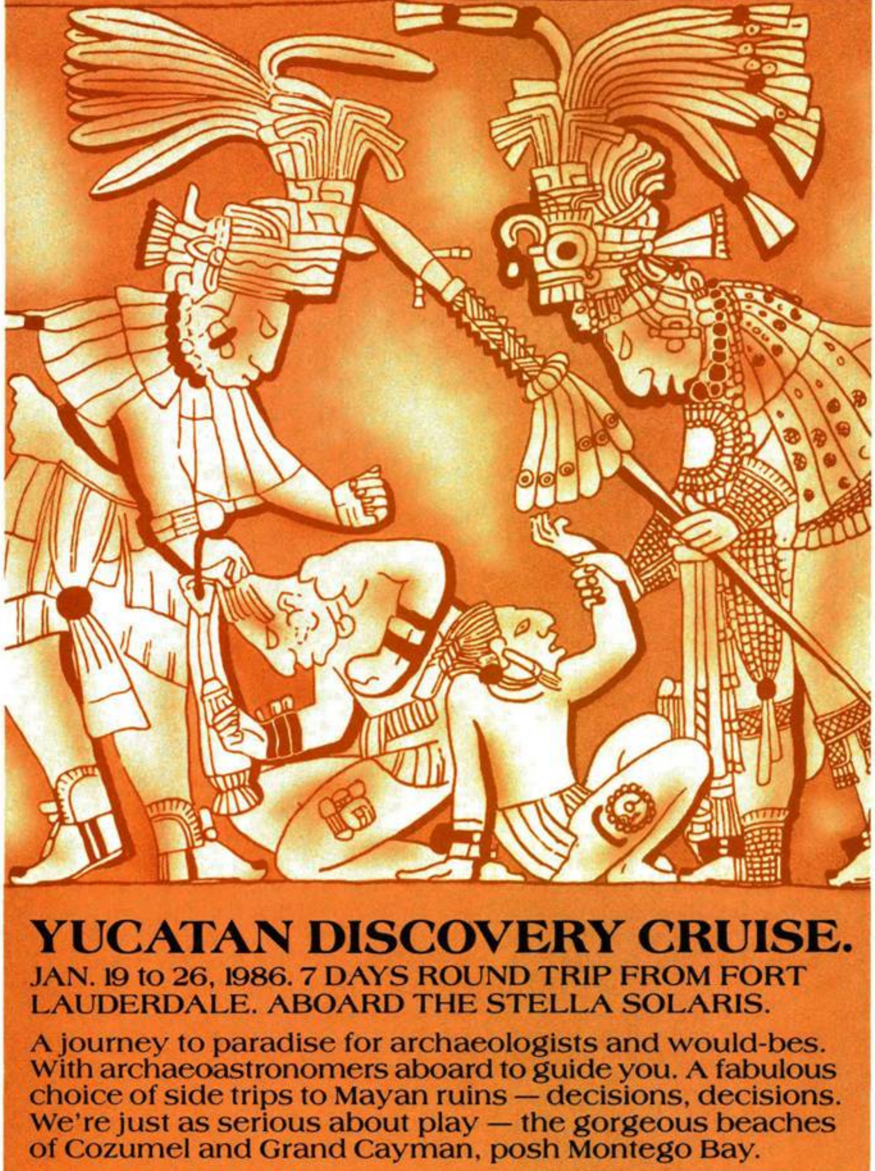

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realized the tube would not go down far enough from that added height so I broke it down and reassembled it on the ground. In my haste, I nearly wrecked the scope and my back.

Running out of time and breath, I finally found the hazy spot in the finder, popped in a 20mm Erfle, and focused. No photo of the Omega will ever rival what I saw that night! Even through the shimmer, light pollution, and oak leaves, I could see many resolved stars highlighted against the massive core. Higher powers were useless due to the poor seeing, so I stayed with the 20mm lens. I watched enthralled until the great mass of stars finally slid behind the trees and disappeared. It had been a good night. I had seen the great Omega.

Robert Bobo
Jackson, TN

Notes from a Starry Night

Jupiter was a commanding sight due South, Arcturus shone about 46° above the horizon in the west, and Cassiopeia was just coming into view in the northeast. The temperature was 72 degrees, cooling from a record-breaking 90. Thin cirrus clouds drifted gently from the south-southwest, at times briefly obscuring Jupiter.

There was no sign of the house finches, pine siskins, rufous-sided towhees, dark-eyed juncos, and raucous Steller's jays that had been calling from the trees an hour earlier. They were there, though, perched on delicate feet, heads tucked under wings. Soon the common nighthawk would begin its August migration through the night sky.

How do they know when to go? Do they orient themselves by Polaris, Ursa Major, Antares, or Jupiter? Is there, within their remarkably fragile bodies, some mechanism tied to Earth's magnetic field? How astounded early astronomers must have been when through their telescopes they saw flocks of birds dotting the Moon's face. Researchers still haven't solved the mystery of bird migration. Here, for amateur astronomers, is another kind of wonder and study.

How many have, in their youth, found a special place high on a hill to watch the sky — a place to sit contentedly and just let the imagination wander? What are stars? Where did we come from? Why are we here?

"When you wish upon a star, makes no difference what you are." I was parked on my footstool in the middle of our road back in the second-growth woods, a victim of summer insomnia. Delightful memories came to me of idyllic nights and pollution-free times — of holding another's hand and together saying, "Grant this wish I wish *tonight.*" By the time Jupiter's motion and Earth's rotation hid the great planet behind a towering hemlock, my mind freed itself from the present and eased back in time.

The late '30's was an era of few cars, so to reach such places my friends and I would go by streetcar or bus to the end of the line and then walk to our chosen destination. Occasionally we'd take a streetcar ride to the old five-cent ferry that ran between San Diego and Coronado Island. We'd stay on the ferry for hours, refreshed by the wind and sometimes entertained by a school of porpoise as they played alongside. Once and a while, we'd leave the ferry and walk to the sea wall. There, perched upon a giant boulder, we enjoyed a sense of security beneath the sky's panoply of stars and were lulled to dreams by the gentle surf. It was as though we were bound to the Earth, the sea, and the sky. Total cost for this simple pleasure including transportation and a mixed fruit sundae on the way back was 30 cents.

We were not entirely problem free then. Headlines read much the same as now, proclaiming "No Jobs," and far across the Atlantic a threatening "star" was rising whose twisted dreams would darken the starry nights with war. All too soon there were blackouts. Japanese friends disappeared. Our days of diving in the breakers (the neat kind that flipped one over in a resounding bellyflop) at La Jolla and Pacific Beach were tainted by concerns over submarines or floating mines.

No longer were we looking ever upward and onward, but straight forward — bent upon the path of today. There might not be a tomorrow. Our childlike wonder of the sky was replaced by awe of the Flying Fortress.

There were chilly winter mornings when the Moon's reflection on flying planes caused us to exclaim, "How beautiful." I still marvel at man's ingenuity to fly nearer the stars, but am now moved more by the sight of three crows chasing a red-tailed hawk. The birds hover, flutter, soar, dive, and circle until finally the exhausted hawk climbs high toward the Sun, ending the battle in a draw. Possibly only fighter planes can match such magnificent aerial maneuvers.

At times the aircraft company where I worked called for volunteers to participate in some scientific experiment. Up my hand would go, ever the incurable romantic. But advancing years have somewhat tempered my eager hand. If I were around to participate in a space colony, I'm not too sure I'd apply. I cannot see anywhere in written history that man has changed his ways enough to make such a venture successful. There will always be among us Poobahs, Ghengis Khans, and William the Conquerors.

One must not dwell upon negative overtones. We have done some things right — conquered smallpox and polio, for example, and one day we shall win the battle against cancer. We have decreased infant mortality and increased our average life span. In a personal sense, I now see through a plastic lens implanted following cataract surgery. This innovation was an outcome of World War II when doctors in Great Britain developed the technique.

The world of science has opened doors to thee and me, sharing its findings of outer space, biology, geology, volcanology, and medicine.

Not all of the data from the Infrared Astronomy Satellite has been sorted, but remember the news of small solid particles orbiting Vega? And the discovery of Comet Tempel 2's 400,000-kilometer tail? We "traveled" with Voyager. We were "in" on the discovery of Saturn's rings and the volcanoes of Io. We "participated" in the Viking mission to Mars and look forward to the Galileo mission to Jupiter planned for 1986.

Ursa Major was hidden northwest by the cedars. Antares, Mars, and Saturn had moved farther southwest and were enshrouded by persistent clouds.

Husband Tom's gentle snoring greeted me as I came in. I smiled, remembering how the starry nights had changed our lives. On Christmas of 1982, he gave me an 8-inch telescope to replace my 4-incher. My husband had not yet acquired a zest for astronomy, content as long as I was happily engrossed. The first night that we set up — a cold, clear, January evening — we took turns zeroing in on M-31, M-1, M-42, and everything else we could see. Guess who operates the 8-incher now, accompanied by a well-thumbed Messier guide? It's okay. It was a bit too heavy for me, anyway. And there was one clear night last November when we nearly tumbled over each other to set up, only to be greeted by a search beam sweeping the sky. It was heralding a new pizza parlor. But there was September of '83 when we went east of the Cascades to Lake Chelan and combined golf during the day with viewing at night. We even saw Fomalhaut, which isn't easily visible from Redmond.

Already the night was a special memory. But before my journey's end on planet Earth, there will be many more starry nights to share.

Marty Murphy
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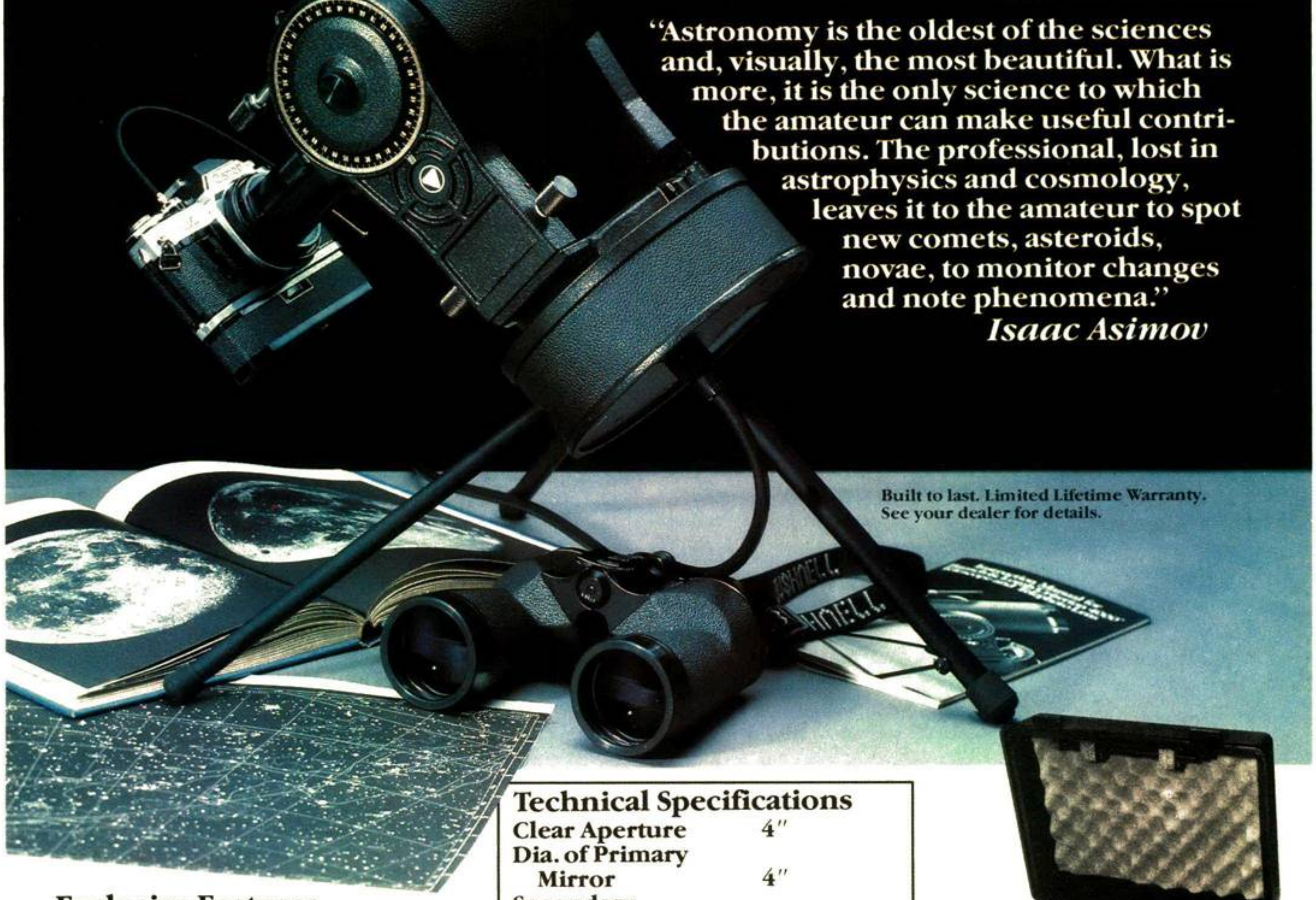

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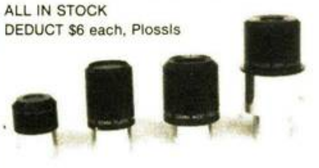

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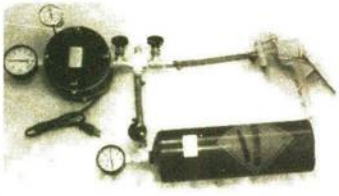

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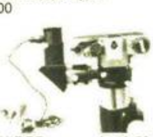

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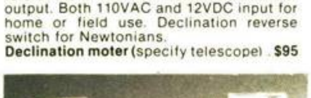

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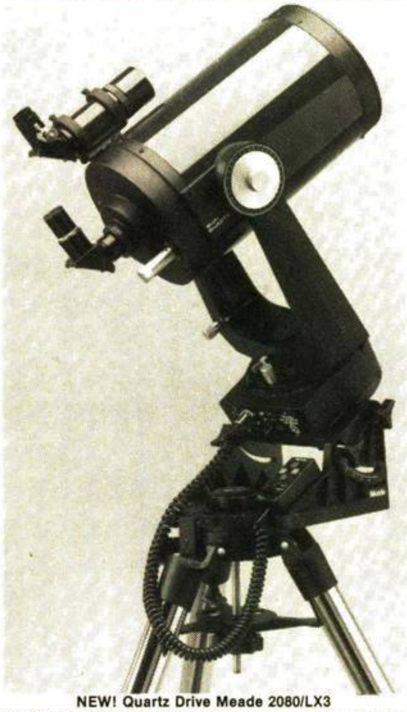
#38 declination motor & clutch .... **add $99**
Dew shield and accessorv trav .... **add $89**



NEW! Quartz Drive Meade 2080/LX3

The Meade 2080/LX3 with built-in quartz electronic drive system is positively the highest performance 8" Schmidt-Cassegrain telescope system available today.

- ★ Certified diffraction-limited optical system
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- ★ 8x50mm right-angle illuminated Polar viewfinder
- ★ Multi-coated prism star diagonal (99% transmission)
- ★ 25 ft. cord for field operation from a 12V car battery
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- ★ Equatorial wedge with compass, bubble level, micro metric azimuth control
- ★ Piggyback camera mount for effortless wide-field photography (**Best to photograph Comet Halley!**)
- ★ Audio cassette explains features, set-up, visual & photographic applications

FEATURES OF BOTH 2080/LX2 & 2080/LX3

- ★ Lifetime warranty on telescope, wedge, tripod
- ★ 8"f/10 Schmidt-Cassegrain optics, F = 2000mm
- ★ 20mm Research-Grade Erfle 1¼" eyepiece (100X)
- ★ 7mm Research-Grade Orthoscopic eyepiece (286X)
- ★ High transmission coatings on the front corrector lens
- ★ Ultraprecision 6" LX worm gear motor drive
- ★ Oversize 8.25" primary mirror benefits photography
- ★ Convenient fork mount with slow motion controls
- ★ Best overall mechanical stability of any 8" Cassegrain
- ★ Large right ascension & declination setting circles
- ★ Padded carrying case
- ★ Eyepiece rack
- ★ Lattitude scale and no-tool knob set
- ★ Adjustable height heavy duty tripod with eyepiece rack
- ★ Dew shield & accessory tray, optional **add $88**
- ★ Star map & finder cards for Messier objects
- ★ Red astronomer's night flashlight
- ★ Optional multi-coated/silvered optics boost transmission 18%

2120/LX3 10" System $2695

The 10" Meade 2120/LX3 collects 56% more light than an 8" telescope for significantly improved viewing and astrophotography. It has all the features of the 2080/LX3 (see above.)

Meade 2120/LX3 w/wedge & tripod ($4500 List) ... **$2695**
Multi-coated/silvered optics boosts transmission 18%
Highly recommended! **$195**
#710 dew shield (10") Essential!.................... **$98**
#36 dual-axis drive corrector control box **$99**
#38 declination motor and clutch.................... **$99**
LUMICON Giant EASY-GUIDER/Rich-Field viewer for f/4-f/10 operation (state camera).................. **$359**

4" MEADE 2045 w/ table tripod . . . $650

$650

IDEAL FOR
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Meade Model 2045 — Advanced engineering and superb optical performance in a beautiful ultraportable system.

FEATURES OF THIS TELESCOPE

- ★ 4"f/10 Schmidt-Cassegrain optics, F = 1000mm
- ★ High transmission coatings on front corrector lens
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- ★ Sturdy fork mount with setting circles
- ★ Manual slow motion controls
- ★ Star map & red astronomer's flashlight

HIGHLY RECOMMENDED OPTIONS

Model 43 drive corrector uses 12VDC ($120 List) **$96**
See Meade 2080/LX2 options
Wedge & field tripod as for 2080/LX2 .... **$298**
Dew shield..........**$45** Solar Filter..........**$126**

80mm REFRACTOR $495

Model 310 ($700 list) **$495**
Excellent for both terrestrial & astronomical viewing 80mm (3.1") f/11 refracting telescope includes 1¼" focuser, 6x30mm finderscope, 36X and 100X 1¼" eyepieces, adjustable height tripod with accessory tray, and alt-azimuth mount with slow motion controls.
Model 320 ($900 list) **$630**
Identical to 310, but has equatorial mount with setting circles.
Quartz motor drive**$169**
Basic camera adapter **$32**
Easy-Guider (state camera)........**$149**

OPTIONS BOOST PERFORMANCE

LUMICON UHC Filter for nebulae. Standard 1¼" **$79**
Prem 1¼", **$99;** Std 48mm, **$149.50;** Prem 48mm,**$189.50**
LUMICON Deep-Sky Filter, 1¼" Premium **$79**
48mm Prem Deep-Sky .....**$119.50, $99.95** w/ Easy-Guider
Adapter for viewing w/ 1¼" eyepiece **$20**
Dust Covers. Keep optics clean. For 6" **$16/pair**
8" ....**$20/pair;** 10" ....**$18;** 16" **$24**
LUMICON Rich-Field Viewer (2080) **$120**
LUMICON Newtonian Easy-Guider, 1¼" or 2" **$149**
#122 2X Barlow ($60 list) **$48**
Dual-axis drive corr. and elec. dec.: for 2080/LX2 .....**$298**
for Model 628, 826, DS-10 .....**$310** for DS-16 .....**$420**
Tele Vue 32mm Plossl 1¼" eyepiece **$88**
LUMICON Cassegrain Easy-Guider for 2080/LX2 & /LX3 (state camera).................................**$199**
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6"f/5 NEWTONIAN $695

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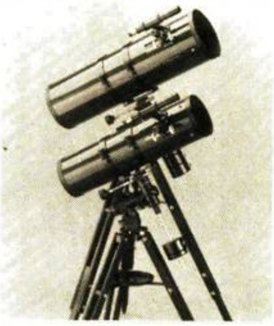


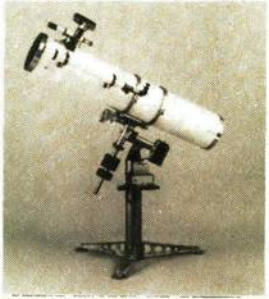
Models 6600 (6"f/5) & **8800** (8"f/4.5) telescopes
Model 6600, 6"f/5 Newtonian telescope ($1100 list) . . .**$695**
—Best performance & value; bright, wide views.
Model 8800, 8"f/4.5 Newtonian Telescope ($1400) **$895**
—Collects 78% more light than a 6" telescope.

These Meade Professional Series reflecting telescopes yield superb rich-field viewing w/ bright images. They include an equatorial mount w/ adjustable tripod, setting circles, slow motion controls, 6x30mm view-finder, 1¼" focuser, 25mm & 9mm 1¼" eyepieces, & accessory tray.

#784 Quartz motor & quartz drive corrector..........**$169**
Basic camera adapter (for moon & planets) **$32**
1¼" LUMICON Easy-Guider (state camera) **$149**

8"f/6 NEWTONIAN $890

GET
READY
FOR
COMET
HALLEY



Model 826, 8"f/6 Telescope w/ accessories

Model 628, 6"f/8 with motor drive ($1220 list) **$785**
—Best telescope for all visual use, superb optics.
Model 826, 8"f/6 with motor drive ($1396 list) **$895**
—Collects 78% more light than a 6" telescope
Model 826C, 826 w/ 2" focuser, 8x50mm finder ($1530) **$995**

These Meade Deluxe Series reflecting Telescopes have superb image quality at low or high power. They include an equatorial mount with motor drive, pier, legs, setting circles, 1¼" rack & pinion focuser, 6x30mm finderscope, 25mm (48x) and 9mm (135x) 1¼" eyepieces, altitude and azimuth fine adjustments for polar alignment.

#43 drive corrector uses 12VDC ($120 list).............**$96**
#47M Dual-axis drive corrector & elec. dec. **$340**
1¼" or 2" EASY-GUIDER (state camera).............**$149**

16" f/4.5 NEWTONIAN $1995

GET
READY
FOR
COMET
HALLEY

Meade DS-16A with Accessories

The DS Series of 10" and 16" reflecting telescopes are ideal for deep-sky viewing and photography.

DS-10A, 10"f/4.5 with motor drive ($1510 list) **$995**
—Gathers 56% more light than an 8" telescope
DS-16A, 16"f/4.5 with motor drive ($3050 list) **$1995**
—Gathers 400% more light than an 8" telescope

Both the DS-10A and DS-16A telescopes include an equatorial mount, #680 2" focuser, motor drive, setting circles and 25mm 1¼" eyepieces.

6x30mm finderscope with brackets ($46 list) **$39**
8x50mm finderscope with brackets ($114 list) **$89**

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ASTRONOMY

In Focus

Our Dyna Soar

Sir / I read with great interest your Forum article on the Dyna Soar program (June 1985 issue). I'd like to add, however, that Boeing was not the only contractor involved in this program. Martin-Marietta was also developing a mini-shuttle early in the 1960s.

They constructed two full-size mockups before the program was cancelled. The Martin design was quite similar to Boeing's, but it had a central fin and room for three men.

Both mockups were exhibited at the 1964 World's Fair in New York — some readers may recall seeing them — but were left to quietly deteriorate at the site for the past 20 years. In early 1985, we obtained one and restored it to the appearance it would have had as a flight vehicle (see photo). It even came with three mannequins in Mercury-type space suits!

The other mockup is still sitting at the World's Fair site, eagerly awaiting a museum to retrieve and restore it.

Joshua Stoff
Assistant Air & Space Curator
Cradle of Aviation Museum
Museum Lane, Mitchel Field
Garden City, NY 11530

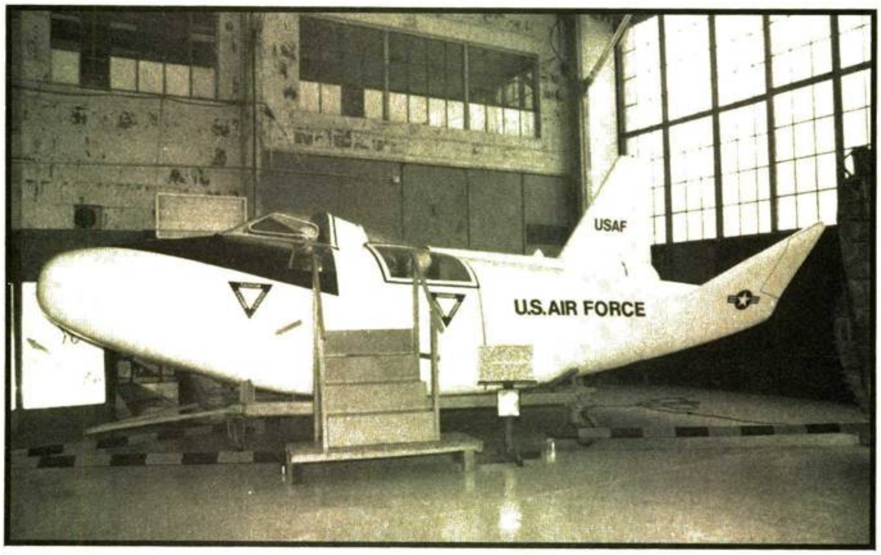

photo by Joe Davis

Tahiti, Yes!

Sir / I would like to comment on the letter "Halley from Tahiti?" on page 33 of the June '85 issue. It stated that the island of Tahiti is a poor location to observe Comet Halley because of the high mountains southeast of Papeete.

Actually, the view from any dark-sky area near Papeete should be spectacular. On April 11, 1986 when Halley is closest to Earth and near its southern extreme, it will rise at 6:21 p.m. local time at azimuth 140° behind the mountains. Tall as they are, these mountains rise only about 15° or so above the horizon. Halley will provide a beautiful sight as it rises above them in the early evening. The comet will reach an altitude of 60° by the time it crosses the meridian at 1:42 a.m. local time and will still be high in the southwest at sunrise, setting at 8:57 a.m. local time at azimuth 220°.

I will gladly face all the unknown dangers of an expedition to Tahiti to test this theory and resolve the question. Donations gratefully accepted.

Dale E. Ireland
Vancouver, WA

P.S.: I bet Bora Bora won't have too bad a view, either.

2010: The Pro Side

Sir / I take strong exception to Ray Grasshoff's review of *2010* (ASTRONOMY, April 1985). His criticisms of minor technical inaccuracies were extremely narrow-minded, causing him to overlook the films' excellent effects, soundtrack, story, and cinematography.

I thought *2010* had plenty of technical content. The thin ring around the planet Jupiter and the accumulation of sulfur on Discovery applied up-to-date knowledge about the jovian system. The use of an inflatable balloon for aerodynamic braking and the tandem use of both spaceships for the final escape were marvelous examples of sound engineering and scientific principles.

Grasshoff attempts to make comparisons between *2010* and *2001*, but of course there aren't any. *2001* was an outright con perpetrated on an unsuspecting public. The movie of 15 years ago was full of "golly-gee-whiz" space stations, eerie monoliths, and super-computers that weren't. It also had a story line that insulted the intelligence of the viewer.

My point is this: Most research in the United States depends on funding based on public acceptance of the merits and benefits of technology. No doubt Mr. Grasshoff has a scientific mind that can easily visualize the drama and excitement of technical discovery. I hope I share these visions, too.

But the man and woman in the street need assistance in conceptualizing the future. High-quality films like *2010* help provide these images. Unfortunately, *2001* spoiled the dream for many people and this effect lasted until George Lucas rescued us with his *Star Wars'* saga.

Let's hope there are many more movies like *2010*.

Thomas Bonham

You are Cordially Invited . . .

Sir / The Cederberg Observatory, a professional-amateur astronomical research group in South Africa, invites amateur societies to observe Comet Halley with them during March and April 1986.

Our observatory, located 160 miles north of Cape Town, is at an altitude of 2900 feet under exceptionally dark skies. Facilities include several large reflectors, astrophotography equipment, a gas-hypersensitization laboratory, and concrete piers for guest telescopes. Slide shows and star parties are held nightly. Accommodations are provided in modern mountain cottages.

Interested parties should contact the undersigned.

Sven Sperbund
Cederberg Observatory
P.O. Box 5433
Cape Town, 8000, South Africa

Astronomy Software List

Sir / An annotated list of astronomical software for home computers has been published by the Astronomical Society of the Pacific. The list includes 45 programs available on disk or cassette for computers such as Apple, IBM, Commodore, Atari, and TRS-80. Each listing briefly describes the software and prints the address of the manufacturer. A list of reference books is also included.

To obtain a copy, please send a donation of $1.00 (to cover our postage and handling costs) to:

A.S.P.
Computer List
1290 24th Ave.
San Francisco, CA 94122

Andrew Fraknoi
Astronomical Society of the Pacific
San Francisco, CA

In the Right Degree

Sir / I found Roger Browne's program for computing the ephemeris of Comet Halley (ASTRONOMY, February 1985) most enjoyable. I've used the program on my TI-99/4 to chart the path of the comet through the sky. In so doing, I discovered a minor bug in the declination routine: when the minute value is zero, then declination is one degree too low. Inspection of the program shows that while provision is made to correct degree and minute values when the program arrives at a value of 60 minutes, the line that determines the degree value (1350 in the original version) follows, rather than precedes, the correction steps.

A simple rearrangement of lines 1310 through 1350 corrects the problem. Original line 1350 becomes line 1320, and original lines 1320 through 1340 are renumbered 1330 to 1350 as shown.

```
1310 LET K1 = ABS(Y2)
1320 LET G1 = INT(K1)
1330 LET W1 =
      INT((K1−INT(K1))*60+.5)
1340 IF W1 = 60 THEN LET G1 =G1+1
1350 IF W1 = 60 THEN LET W1 = 0
```

I also noticed that the calculated values for magnitude vary consistently by −0.6 from those given in The Backyard Astronomer. Assuming yours are the correct values, increasing the constants in lines 1470 and 1480 to 4.7 and 5.6, respectively, brings agreement.

I've enjoyed working with the computer programs presented in ASTRONOMY. Let's have some more.

Walter E. Egan
Louisville, KY

— Thanks for noting and correcting a significant bug in the HALLEY.BAS declination routine. Those using it should make this correction. Users should also be aware that predicted comet magnitudes don't really mean much. In The Backyard Astronomer, we're using "official" JPL ephemeris values based on a rather conservative model for Halley's brightness. HALLEY.BAS uses somewhat more optimistic values. At this point, however, nobody knows *how bright the comet will be.*

Ooops!

The Halley amateur astrophotographic prize of $100, mentioned in "Find Halley's Comet by Blinking" (February 1985), was offered by the Problicom Sky Survey.

Behind the Scenes

Who'll Be the First?

The Orion Nebula? On the cover? In August? They've got to be crazy!

Well, maybe we are. But astronomers don't forget about a sky object merely because it's not high in the sky at night. You're likely to find astronomers hard at work this summer, analyzing measurements made last winter or even several winters ago. Nowadays, for a professional astronomer, observing often consists of studying plates or processing data tapes that are months or even years old, and astronomy consists of writing a computer program "model" to check out the fit between theory and the observed universe. This month our feature article explores the world of the satellite astronomer and we conclude our three-part series on balloon astronomy by Sten Odenwald. If you haven't already read the first two articles in the series, take time to read all three together. We think you'll enjoy them.

For amateur astronomers, the mid-summer days are long and the nights are short. Most of us living in what geographers euphemistically call "the temperate zone" do the bulk of our observing in summer because winter is cloudy and cold. With Halley's Comet coming back in the depths of our cold season next winter, though, we can't indulge ourselves by staying indoors if we want to see it. Since everything becomes 10 times harder to do when the temperature drops below zero, *now* is the time to hone your observing skills.

And speaking of now — would you like to be the first kid on your block to recover Comet Halley? It shouldn't be too difficult. The first good observing window occurs in mid-August (that's this month!) in the pre-dawn sky. Comet Halley should be a 13th magnitude fuzzy patch in Orion's upraised club at the location shown in our finder chart on pages 51 and 52. We're looking forward to hearing from you when you spot it — and are eagerly awaiting your pictures of Comet Halley in our mailbox. For photos, make sure your name and address appears on every print or slide, include a note giving observing circumstances and technical data, then wrap securely and mail to: ASTRONOMY, Box 92788, 625 E. St. Paul Ave., Milwaukee, WI 53202.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

MEADE 2080, complete with all standard accessories, wedge, and tripod, $2250 list, for **$1399**!

$1399

Authorized Meade Dealer

Why wait for your telescope?

We have 200 in stock!

In this year of Halley's Comet, with over-worked manufacturers taking as long as five months to fill telescope orders, no dealer can guarantee immediate shipment on every telescope. But, with more than 200 telescopes in our stock — and more on the way — you've got a better chance at getting immediate shipment from Ad-Libs Astronomics than from virtually any other telescope dealer.

Why buy your scope from us? Here are five good reasons . . .

- **We have scopes in stock.** More than 200 in inventory at the time of this writing (June '85), and more than 500 scheduled for delivery over the next few months — all discount-priced. All the best scopes, too — like the Meade 2080/LX2 and LX3, the Meade DS-10A, the Celestron Super C8 Plus, the Bausch & Lomb Criterion 4000, the Edmund 2001 Astroscan, and more. Some dealers can't even *get* the scopes they're advertising at super-low prices. When you order from us, we don't give you vague promises. We give you fast delivery.
- **We have accessories in stock.** Some dealers have low prices on scopes, as we do, but have to special order every accessory — and that takes time. We keep over 500 eyepieces in stock, 250 camera adapters, 125 Barlows, and more — so we can give you quick delivery and low prices on accessories, too.
- **We give you all manufacturers' accessories.** We don't strip our telescopes of finders, cases, and eyepieces for later sale so we can show an artificially-low selling price. We have only factory-fresh telescopes, complete with every part the manufacturer normally supplies. Our prices are low because our overhead is low and our volume is high.
- **Low prices and free freight.** Our discount prices can save you up to 40% on telescopes and up to 25% on accessories. And, unlike some dealers, we don't add huge freight charges that make seeming bargains not such good deals after all.
- **We're experienced, and we're in astronomy for the long run.** Some dealers who have popped up lately are out to make a quick profit on Comet Halley, only to fade away again as the comet does, so their clerks often don't have much telescope experience. We've been helping amateur astronomers save money on the right scopes for over six years — and we plan on being around a lot longer, to continue to give you good advice and save you money even after the comet goes.

$1649

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How to Find Halley's Comet

The long wait will soon be over — all the fuss, all the predictions, all the ranting and raving from the press. After months and months of build-up, we're now ready for the reality of Comet Halley. In the end, it will boil down to just one thing — how Comet Halley looks in *your* telescope's eyepiece. By early August, this famous periodic comet will move out of solar conjunction and should soon be brightening to the point where backyard observers can find it. By this winter, it should transform from a dim featureless smudge to — hopefully — a full-fledged, naked-eye comet.

Before going further, however, a word about predictions. Although professional astronomers have monitored Comet Halley for over two years and its orbit is quite well-known, Halley's appearance is not equally certain. The expected magnitude and behavior of Halley at any given point in the future are predictions only: It won't necessarily do what we think it will. The predictions used in this article are from *The Comet Halley Handbook*, 2nd edition, by Donald K. Yeomans and Zdenek Sekanina, published by the International Halley Watch.

Between August 1 and the end of October 1985, Comet Halley stays in the same small part of the sky but undergoes a dramatic brightening. The comet is far enough away from the Sun to be seen in the predawn sky in early August, but viewing then is hampered by moonlight. As with deep-sky observing, the unfortunate and often ill-timed interference of the Moon means that there will be only three prime (i.e., Moon-free) periods for observing Halley's Comet between August and November — two-week "windows" in August, September, and October.

August: Large Telescopes and Patient Eyes

During the first week of August, the Moon obliterates any reasonable hope of detecting the comet; on the 10th, 11th, and 12th the Moon's waning crescent lies close to the Orion/Gemini border, where Halley lies. Finally, on the 13th or 14th, you can at last make your first attempt to recover Halley's Comet. At that time, it lies near Orion's raised arm and club; it should have risen high enough to see around 4:00 a.m. local time. The crescent Moon will still hang low in the predawn sky, but may be far enough out of the way to enable you to spot the comet — predicted to be shining at about magnitude 13.4.

When Halley's Comet becomes visible, it will appear as a faint smudge. Photo of Comet Kohler by Orien Ernest.

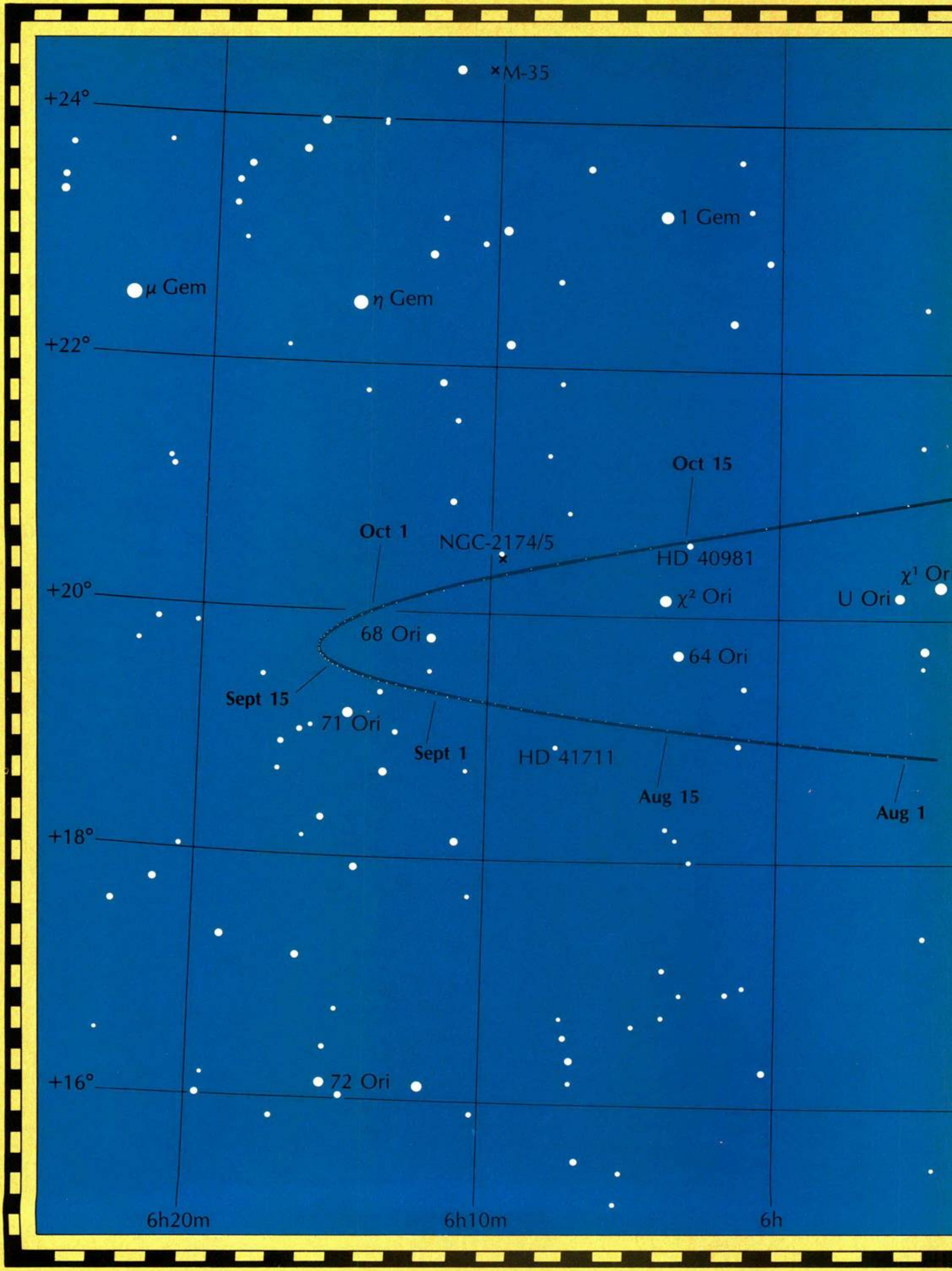
Before you go outside with your telescope, study the finder chart on pages 36 and 37. It shows the region of sky from 5h25m to 6h25m in right ascension, and from +15° to +25° in declination (epoch 2000.0 coordinates). Inside this 150 square degree rectangle of sky are the northernmost part of Orion (where the comet begins its motion across the sky), the left feet of Gemini, and the entire eastern half of Taurus (the bull's horns). The map shows stars down to eighth magnitude, the comet's apparent path, and various bright deep-sky objects such as M-35 in Gemini, M-1 in Taurus, and NGC-2174/5 in Orion.

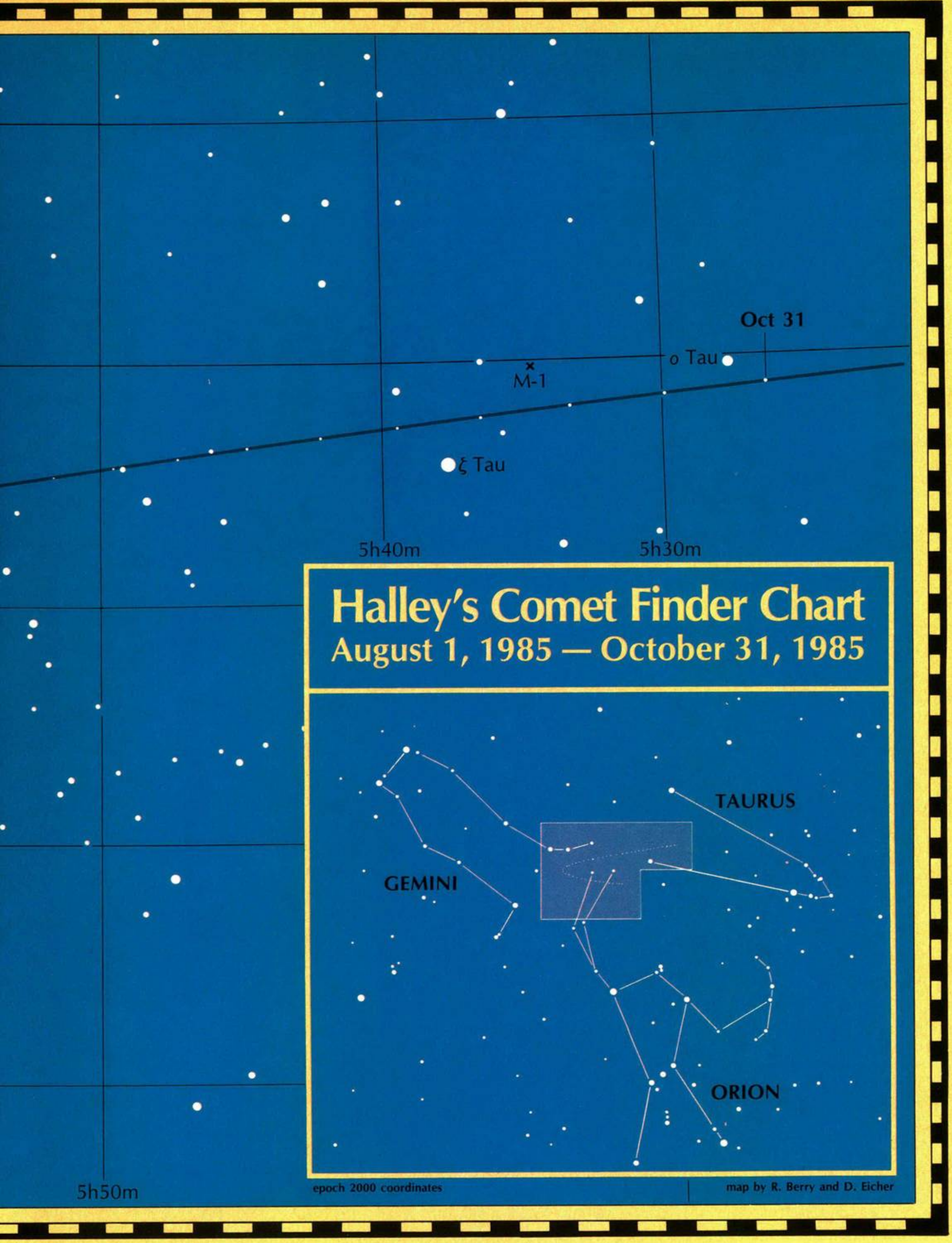
Star hopping is easy in this region. It abounds with bright "key stars" from which you can offset your telescope, so you won't have to bother with precision coordinates, setting circles, or tracking your telescope on the stars. All you need to do is find the right section of sky and the key stars; then using the finder and a low-power eyepiece, slowly sweep the telescope's field of view in the predicted area. The comet is relatively faint during August and its motion is slow. If your telescope shows Comet Halley one night, you should have little trouble finding it the next night.

If you have an equatorially-mounted telescope, it is easy to find the four cardinal directions for slewing the scope. But what if you have a Dobsonian? Simply watch the stars drift: they'll move toward the west. East is the reverse direction, while north is toward Polaris and south is away from Polaris.

If the sky is clear on August 13th or 14th, take your scope outside at about 3:00 a.m. local time and let it equilibrate with the outside temperature. You'll soon see Orion and Taurus rising in the east, marking Comet Halley's position. You won't see the comet yet, however, so don't get impatient. Align your finder scope, let your eyes dark adapt for half an hour, and give Halley time to rise high enough above the murk hanging low on the horizon.

Looking through your finderscope, start with the field containing the western feet of Gemini, your jumping-off point. The two brightest stars in the area, Mu (μ) and Eta (η) Geminorum, are valuable key stars: They shine at magnitudes 2.9 and 3.3, respectively, and are easily recognizable with the naked eye or in binoculars. Move from Mu to Eta, and continue an equal distance westward, then near a degree north, to the magnitude 4.2 star 1 Geminorum. (To confirm these stars' identities, note the large, scattered open cluster M-35 some 2° north. It forms an isosceles triangle with Eta and 1 Gem.) You'll soon get to know this field of stars very well — they are important starting points for finding Halley during the next three months.


M-35
+24°
1 Gem
μ Gem
η Gem
+22°
Oct 15
Oct 1
NGC-2174/5
HD 40981
+20°
χ² Ori
U Ori
χ¹ Or
68 Ori
64 Ori
Sept 15
71 Ori
Sept 1
HD 41711
Aug 15
Aug 1
+18°
+16°
72 Ori
6h20m
6h10m
6h



Halley's Comet Finder Chart
August 1, 1985 — October 31, 1985

Oct 31
o Tau
M-1
ξ Tau
5h40m
5h30m
5h50m
TAURUS
GEMINI
ORION

epoch 2000 coordinates

map by R. Berry and D. Eicher

Having found 1 Gem, swing the telescope southward in declination some 3½°. There you will find a pair of stars in a relatively isolated field; these are Chi^2 (χ^2) and 64 Orionis shining at magnitudes 4.6 and 5.1, respectively. These stars are bright enough that you'll have no trouble spotting them in the finder.

You are now inside the retrograde loop Comet Halley will travel during the next three months — if your telescope is large enough to show it, you are now very close to spotting it. On August 13th or 14th, trace a line from χ^2 to 64 and extend it an equal distance beyond. Halley's Comet should lie within your telescope's low-power field of view.

If you find Halley early on, it will probably be a memorable — although none too impressive — sight. If you don't see the comet right away, remember that it's continuously brightening. Although no one knows how bright Halley will actually be, a 10-inch telescope will probably be adequate for Halley in August. It should be easier to find with a larger instrument, especially if Halley turns out to be fainter than predicted.

From August 15th until almost the end of the month, the Moon will stay out of the way as Halley slowly moves eastward and gradually brightens. To find the comet during this period, start by locating η Gem, 1 Gem, χ^2 Ori, and 64 Ori; sweep from χ^2 through 64 Ori and continue an equal distance south, then slowly scan a degree or two eastward.

By the 22nd of August, Halley will shine at around magnitude 13.1 and lie just half a degree north of HD 41711, a magnitude 7.8 star.

Halley's slow movement and brightening during the August observing "window" conspire to make it easy to find and identify, since it's the only 13th magnitude fuzzy patch in the area. If you find an object you think is Halley, carefully sketch its position among the faintest stars you can see. When you observe it again the next clear night, the comet will have moved on.

By August 24th or 25th, the Moon slithers back into the post-midnight sky to hamper the comet's visibility once again.

September: A 12th Magnitude Slow-Moving Target

As September begins, the comet — now brighter than 13th magnitude — is still blotted out by the light from the Moon, which is now approaching Last Quarter. By the 9th or 10th, however, the Moon moves out of the way and Halley watchers can resume searching. Because the comet stops moving eastward and begins to retrograde toward the west, it remains within one or two low-power fields of view during the entire month. Talk about a slow mover! Once you star hop to this area and locate the comet, you'll be able to find it in almost the same place for the next two weeks.

Star hopping can now follow one of two approaches. First, start from η Gem (the familiar brightest star in Gemini's left feet), and then move about 3½° south to the wide pair of bright stars 71 and 68 Orionis (magnitudes 5.2 and 5.7). Or you can start with the now-familiar pair of stars χ^2 and 64 Ori and move about 2° eastward to the star 68 and 71 Ori. On September 7th, Halley's Comet lies directly between 68 and 71 Orionis near a dimmer star. By the 9th or 10th, when observing possibilities improve, the comet has moved east and appears directly north of 71 Ori. Halley's movements will have become so gradual that it becomes easy to find with a medium-sized scope but harder to identify by its motion. It's a sitting duck.

By the 10th, Halley shines at (predicted) magnitude 12.3, and will probably look like a typical Virgo Cluster galaxy. By the 15th, it's moving as much northward as eastward and should have brightened another ⅓ of a magnitude. By September 24th when it has turned sharply westward, anticipating its forthcoming rapid sweep of the sky, Halley reaches magnitude 11.5 — bright enough to be visible to experienced observers in practically any telescope. Even if you are still a novice, you shouldn't have much trouble locating the comet with an 8-inch telescope. About this time, however, the Moon returns to the early morning sky, signaling another break in your Halley observing plans.

Comet Halley "Windows"

Periods when the Moon does not interfere significantly with observing.

Date	Halley's Magnitude	Distance from Earth	Distance from Sun
August 13	13.4	3.51 AUs	2.96 AUs
August 24	13.0	3.21 AUs	2.83 AUs
September 9	12.3	2.74 AUs	2.63 AUs
September 24	11.5	2.27 AUs	2.43 AUs
October 9	10.6	1.78 AUs	2.24 AUs
October 22	9.6	1.37 AUa	2.06 AUs

October: Bright and Traversing the Sky

Just as in August and September, the first few days of October are bad for observing Comet Halley. But by the 9th, October's Last Quarter Moon will sink toward the horizon in the predawn sky to unveil Comet Halley's image for another round of comet hunting. Unlike Halley's appearances in August and September, the October appearance follows a different set of rules: the comet will be moving much faster across the sky. This means you'll need a new star-hopping route practically each night. But Halley's brightening from 11th to 10th magnitude more than compensates for its increasing motion and makes it easier to find than during September.

On the morning of the 9th, Halley shines at magnitude 10.6 — approximating a bright elliptical galaxy — and lies just south of the emission nebula-open cluster complex NGC-2174/5 in Orion. Since the nebula is a faint ruddy object, you probably won't see it by eye; you will, however, see NGC-2175, a small star cluster located north of the comet. This might be an interesting challenge for serious deep-sky photographers.

By the 12th, Comet Halley continues on a swift northwestern path and brightens to magnitude 10.4. On the 15th, the comet passes just north of the magnitude 7.2 star HD 40981; Halley then shines at magnitude 10.2 and should be recognizable as a "fuzzy star" in binoculars. By October 20th, Halley's Comet will have moved another 3° northwest to a point directly north of the bright stars, U and χ^1 Orionis. Around this time, the comet shines at magnitude 9.8 and should be visible to all backyard stargazers whenever clear skies prevail.

In late October, we'll probably miss seeing a truly fascinating spectacle. Comet Halley then passes directly between the bright star Zeta (ζ) Tauri and M-1, the Crab Nebula, on October 28th and 29th. Unfortunately, the Full Moon occurs in Aries on the 28th, and will make observing or photographing the comet on those nights very difficult. Give it a try anyway.

At this point we still don't know how quickly or how much Halley will brighten. However, Halley will be *where* it's supposed to be because the orbit is well known. If you have trouble finding it, it will be because the comet is too dim, not because it isn't where it should be. Stay tuned to ASTRONOMY's pages — we'll provide extensive coverage of this grand old comet as it once again tours our night sky.

— David J. Eicher.

Reviews

Odyssey II Dobsonian Telescope
17.5-inch f/4.5 reflector telescope, $995
Coulter Optical Co.

In 1981 when I first learned that anyone could send off $600 and get a 17.5-inch mirror back in the mail, I was stunned. After all, as recently as the mid-1970s a 12-inch telescope was a "monster" instrument — one usually owned by an astronomy club or a few die-hard observers with a taste for looking at faint galaxies. But Coulter Optical Co. made a breakthrough in the early 1980s by offering large, thin, inexpensive mirrors. For deep-sky observers, it seemed too good to be true: a 17.5-inch scope for the price of an 8-inch Schmidt-Cassegrain! (The fact that a Dobsonian can't be used for astrophotography didn't stop many observers.) Needless to say, I bought a mirror. (Later, when I had to move and lost the necessary working space to build a tube, I purchased the premade telescope assembly from Coulter.)

The Odyssey II has an f/4.5 focal ratio, giving it — coincidentally — nearly the same focal length as my 8-inch SCT, but with five-and-a-half times as much light-gathering power. The telescope consists of four parts: a tube, a ground board, a rocker-box assembly, and the mirror. The scope is constructed of plywood coated with a polymer resin and blue paint called "Zolatone." The tube is fairly durable and attractive, but inevitably gets bumped occasionally in transport.

It's a chore to set up and use, and — since the tube is nearly six feet long and weighs over 200 pounds — requires a van or truck to transport it to dark-sky sites. The telescope takes about 10 minutes to set up: I can even do it alone by setting up the rocker box in back of the van and then dragging the tube out. I do not recommend this, however — two people are the sane minimum.

The best way to set up is to have someone hold the ground board vertically while another bolts on the rocker box. After tipping the rocker box so that it sits on level ground, set the tube assembly on top. Now comes the delicate part: after unbolting the hinged "trap door" at the rear of the tube, gently slide the mirror inside its cell — which consists of three 3-point pads, two clips, and a sling to support the mirror's 25-pound weight.

Although you are now theoretically "up and running," you must collimate the mirror with the secondary and eyepiece holder. This is confusing at first, but rapidly becomes easier with practice. Three bolts on the back end of the tube control pressure on each of the three mirror pads, enabling you to align the mirror by turning the bolts to the correct positions. I've found that racking a star in and out of focus with a high-power eyepiece — and twiddling the collimation bolts until the shadow of the secondary looks centered in the out-of-focus star disk on both sides of focus — works rather well.

After spending some 15 to 25 minutes setting up and collimating, you still won't be ready to observe since the mirror and tube assembly usually take at least 30 to 35 minutes to cool down and stabilize so that images are reasonably crisp. At star parties, I normally set up, collimate, and use a friend's 8-inch scope until the Odyssey II cools down.

The wait and trouble of setting up are well worth it. The views provided by this telescope at dark-sky sites are a deep-sky observer's dream. Objects I remember as diffuse blurs in my 8-inch SCT are transformed into bright galaxies or nebulae showing distinct detail. The Odyssey II enables backyard observers to resolve small globulars, inspect subtle colors in open clusters, and *see* — not just imagine — spiral structure in galaxies. It opens up what seems like a whole different universe! The image quality may not please a picky planetary observer, but for its intended purpose — low-power deep-sky observing — the telescope does quite well. Since the Dobsonian design relies on simple altitude/azimuth pointing, you have to move objects back into the field by nudging, pushing, or twisting — but you get used to this after a short time.

Coulter's Odyssey II isn't without problems. The company's decision not to include a finder telescope is silly and understandable only as a shortcut to keeping the advertised price at a bare minimum. Sighting along the tube simply isn't good enough for such a powerful telescope. In short, you'll need to add a finderscope — I recommend an 8x50 or larger.

I also had a disaster with a mirror support bolt: the mirror's weight pushed it right through the trapdoor and it fell clanking on the ground! The bolts were inserted *backward* and had to be reversed to better support the mirror.

Despite its shortcomings, the Odyssey II is a good value. If you're a deep-sky observer, want the capability to see every NGC object, and have the means to transport a large instrument or install it in a permanent location, the Odyssey II is well worth the effort required. *David J. Eicher.*

The Glass Lady
D.J. Savage
388 pages, clothbound, $16.95
Daring Books (1985)

"Assbones. That's what it takes to be a real stick and rudder man: Assbones." So begins *The Glass Lady* (subtitled "The Space Shuttle Novel"); the words are those of William Parker, veteran astronaut, whose role in the American space program dates back to the days of Project Gemini. This novel is the fast-moving story of a frantic space mission — a mission to "rescue" the United States from its "worst embarrassment since the Bay of Pigs."

It seems that the North American Aerospace Defense Command (NAADC) has a problem — an ultrasecret Defense Advanced Research Projects Agency (DARPA) secret laser killer satellite, TRIAD, is flying out of control, but is still very much alive. In fact, TRIAD has already fried a passing Russian reconnaissance satellite, Cosmos 1587. As General Andy Burns says, "TRIAD just sort of looked sideways and got off a lucky shot." But as U.S. Deputy Under-Secretary of State Vosnyk points out, "Our crime . . . is nothing less than space piracy . . . complete with the black flag as far as our treaty with the Russians is concerned."

The U.S. military and administration are desperate to remove the killer TRIAD satellite before it creates any more international incidents. It's Space Shuttle to the rescue! And the Russians agree to keep TRIAD a secret — for a price. They want to be in on the rescue with their manned Soyuz.

The Shuttle is to be launched within four days. NASA concocts a shaky cover story for public consumption — fixing an ailing Landsat — and Parker and his "Number One," Jacob Enright, are "go" for launch.

Colonel Willie Parker has so much of the Right Stuff it hurts — but he's gentle, humorous, and sensitive. Lt. Commander Jacob "Jack" Enright is his young, eager, highly-skilled co-pilot with EVA training in the MMU. The novel follows both men during the four days before the flight — through the revelation of a severely-infected wound on the Skipper's leg (which he's treating with horse antibiotics to avoid tipping off the flight surgeons), Jack's near-fatal accident in the underwater mission training facility, and Willie's visit to his retarded daughter. And then, of course, there's the pre-flight press conference, complete with Jack's ingenuous reply to ABC newsman Jules Bergman's inevitable off-the-wall question: "I want people to think of me and say, 'Who was that masked man?' We didn't have a chance to thank him," and Parker's capsule description of the mission profile, "Get it up, get it done, get it down."

There's evil afoot, too. At a meeting so secret even "Long Rider" in "Mr. Lincoln's house" doesn't know about it, it will be Sleep Tight — game over, curtains — for the Shuttle if the Soyuz spacecraft observing the mission gets blasted by TRIAD. As Admiral Hauch explains, the U.S. will have to plan "the sacrifice of Shuttle Challenger with extreme prejudice . . . ."

"You can't possibly be serious, Admiral."

"As I could possibly be, Dale. If the Soyuz goes in, the Shuttle goes in . . . four men in place of everything which lives and breathes on our sorry, little planet."

"My God, Admiral."

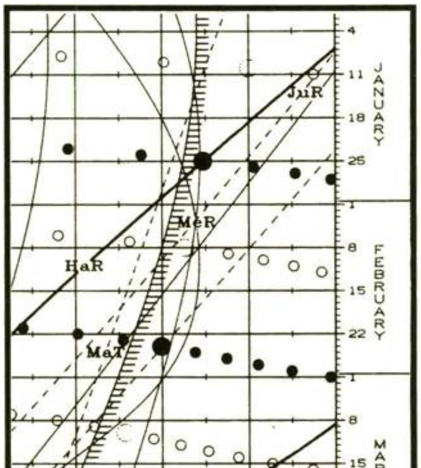
So the novel goes. But it's written with exquisite attention to creating realistic Shuttle operations, right down to detailing every switch and panel on the check list, and this alone justifies reading it. At first the detail seems excessive, but it serves its purpose: the reader flies the mission with Parker and Enright — and Parker and Enright fly the Shuttle as it really is flown. Author Savage's concern for getting it right is underscored by the extensive reference list provided in the back of the book.

Suspense builds as the Shuttle lifts off and matches velocity with TRIAD. Will Willie and Jake get it done and get it down? Can the AC get his swollen leg into the EMU suit and ride the MMU out to TRIAD for the de-spin maneuver? Will the PAM de-orbit TRIAD before they reach the SAA? Will TRIAD zap the Shuttle? Will it zap the Soyuz? Will pilot Parker unknowingly run PTI-7, the fatal Sleep Tight maneuver, thereby immolating the Shuttle and its crew? Stay tuned for the next exciting episode . . . .

Go ahead — get this book and read it. You will enjoy. *Richard Berry.*

The Celestial Ephemeris
Comet Halley Special Edition
computer-plotted celestial event chart, $15 (foreign, $20)
Astronomical Graphics (1985)
Hummel Planetarium
Eastern Kentucky University
Richmond, KY 40475

It looks a lot like the famous "Graphic Timetable of the Heavens," for many years published annually by the Maryland Academy of Sciences, but *The Celestial Ephemeris* is individually computed by the VAX computer and plotted on a high-precision Cal-Comp plotter at Eastern Kentucky University for any longitude, latitude, and starting date you might desire. All for $15.



For those not familiar with "graphic timetable"-format charts, such charts typically plot celestial events — sunrise, moonrise, times of rising and setting for the planets — on grids showing time of day horizontally and date vertically. The slowly changing event times thus plotted form graceful curves on the charts. Want to know when Mars rises on February 15, 1986? Simply find the February 14 line and follow it horizontally until it intersects the MaR (Mars Rises) curve at about 1:55 a.m. on February 15. (The date changes after midnight — remember?)

This year, *The Celestial Ephemeris* is available in a special edition from July 1, 1985 to June 30, 1986 which includes Halley's Comet. For anyone seriously interested in observing the comet, this chart of the exact rise, transit, and set circumstances will greatly simplify planning which moonless nights are best for observing.

Of course, *The Celestial Ephemeris* is by no means a complete guide to observing the planets, the Moon, or the comet, for although it tells you when to observe and when the planets are above the horizon, it provides few clues about where to look. In short, the more you already know, the more such a chart will help you.

Graphically, the chart is a superb bit of modern plotter graphics. Lettering is crisp and readable; lines are continuous, dark, and well-defined. The chart itself is 14" wide by 18" long and centered on a sheet of heavy 18" by 24" paper. The date/time grid and phenomena for the Sun and Moon are plotted in black, while Mercury, Venus, Mars, Jupiter, Saturn, and Uranus are plotted in orange, green, red, blue, purple, and brown, respectively. Halley is represented by a relatively heavy black line.

An interesting situation arose during the plotting of Comet Halley on our review chart. In early April 1986, the head of the comet won't rise for latitudes north of 42° — and Milwaukee is at 43° north! However, the tail may stick up from the horizon as far north as 50°. What happens to the rise and set lines for a comet that neither rises nor sets? On our chart they are dotted, defining the best times to look for the tail low in the southern sky. *Richard Berry.*

The Space Station
Theodore R. Simpson, ed.
295 pages, hardcover, $19.95
I.E.E.E. Press (1985)

This anthology contains 16 chapters that discuss the role of NASA's projected Space Station — "an idea," in the words of the book's subtitle, "whose time has come." The chapters, by such authors as Ronald Reagan, James Beggs (NASA's Administrator), and Harrison Schmidt (the ex-astronaut and senator), are grouped into four categories: historical background, the decision to build the station, station concepts and uses, and the long-term potential. Seven appendices reprint important policy statements, memos, and speeches including Kennedy's Apollo speech, Nixon's Space Shuttle statement, and Reagan's State of the Union address on the Space Station.

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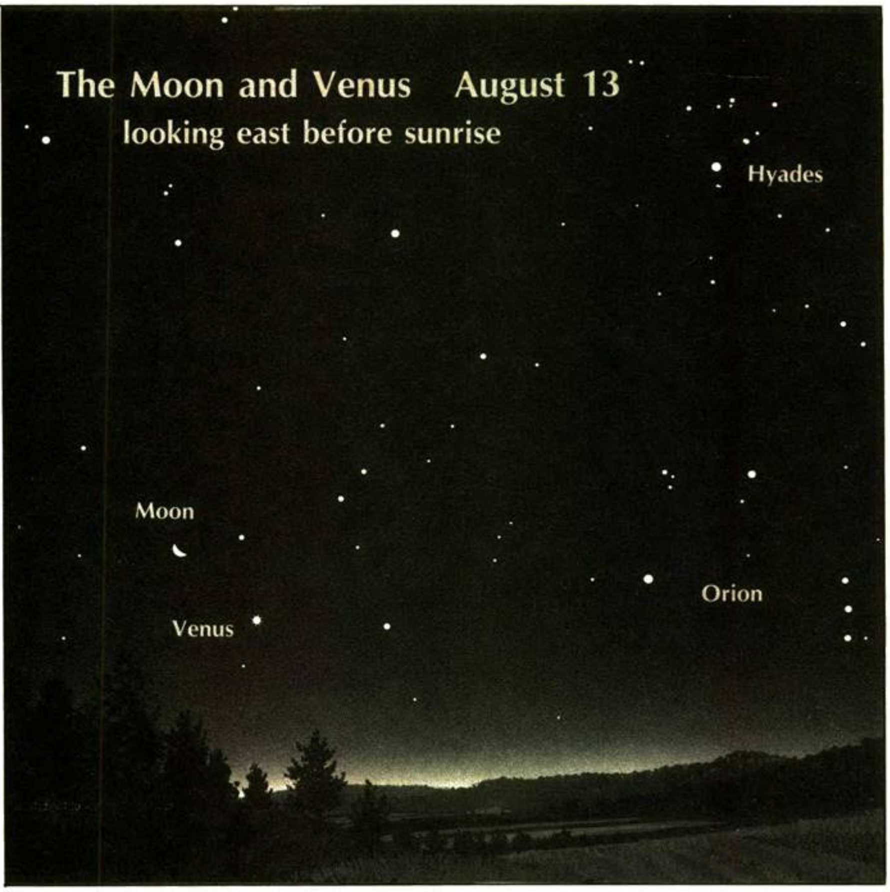
A Month of Great Observing

by Fred Schaaf



The Wanderers

This August has something for everyone. The lengthening nights permit good views of Saturn and the Perseid meteor shower. Venus and Mercury are at highest morning peaks in the sky, and Jupiter is at its biggest, brightest, all-night best.

No matter what time of night you observe, it will be difficult to miss **Jupiter**. The planet is at opposition on August 4 and the next day shines at its brightest, magnitude −2.4. During this opposition Jupiter is 4.07 AUs (about 378 million miles) from Earth — nearly the closest it ever gets to us. Next year's opposition will be the best in Jupiter's 12-year orbit, although it will be only slightly better than the present one. Take advantage of this opportunity: use low-power optical aid to determine the lowest magnification you'd need to make out the planet's disk. Then try to catch a view of all four of the bright Galilean moons when they are farthest from the planet. (A steady tripod for binoculars is a necessity for these observations.) Try about 8 or 9 p.m. on the 7th and 23rd.

This month **Venus** is far from its brightest, but reaches highest altitude for most of us in early August — more than 30° above the horizon at sunrise. Since Jupiter will be setting in the southwest as Venus is rising in the northeast, you will have an excellent opportunity to compare them. With Venus now near the dimmer end of its brightness range, the two planets can be easily seen when they're at a similar altitude. Venus should still shine more than a magnitude brighter than Jupiter, but this is close enough to permit a reasonably accurate comparison of their colors with the naked eye.

Observers at northern temperate latitudes are particularly lucky this month — they will see Venus at maximum altitude in the morning sky nearly 1½ months after greatest elongation. As Venus moves into the far side of its orbit from us, we'll see its altitude decrease and the planet dim. This is your last chance — for about nine months — to see Venus so high and bright in a dark sky.

For information on viewing the Moon, planets, and deep-sky objects with telescopes, see **The Backyard Astronomer**.

Mercury is somewhat more than half as high as Venus in the morning twilight by month's end. It moves through inferior conjunction and reaches greatest latitude south of the ecliptic on August 10, passing almost 5° south of the Sun. The planet then moves into the morning sky to reach a greatest elongation of 18.2° — almost the smallest possible — but the elongation is nearly vertical because of the angle of the ecliptic to the morning horizon. (Of Mercury's morning apparitions in 1985, only December's will be as good.) Greatest elongation occurs on August 28. Don't miss this because a week before or after greatest elongation, Mercury will be only about half as high above the horizon at mid-twilight.

Mars remains hidden in the Sun's glow this month, but **Saturn** is well placed in the southwest evening sky. During August, it passes through eastern quadrature (90° from the Sun) and is very slowly accelerating with direct (eastward) motion in eastern Libra. The planet has faded greatly since its May opposition, and is now only slightly brighter than Spica and Antares. Saturn will remain visible only through the first half of autumn.

A good reason for naked-eye observers to be up after midnight this month is the annual **Perseid meteor shower**. On the morning of the 12th, a crescent Moon rising several hours after midnight will reduce the numbers visible in the prime hours before dawn, but you should still see many bright meteors. The Perseids have been a bit disappointing in recent years, but on a good morning a viewer in a dark sky might see 50 per hour — or even more. Perseid rates are high for several days before maximum, but afterward dwindle rapidly.

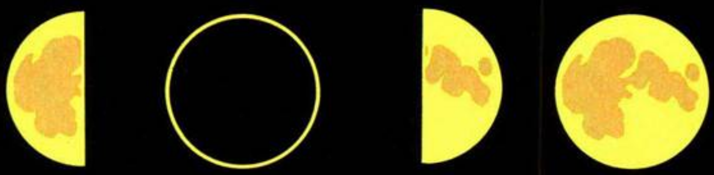
The Starry Sky

The zero magnitude blue-white star Vega is now near the zenith for most of us, but don't let its brilliance make you overlook a classic quadruple star and an interesting naked-eye variable in the tiny constellation **Lyra** the Lyre.

Epsilon (ε) **Lyrae** requires some moderate telescopic magnification to show you the famous "Double Double" — four stars — but the two pairs of Epsilon

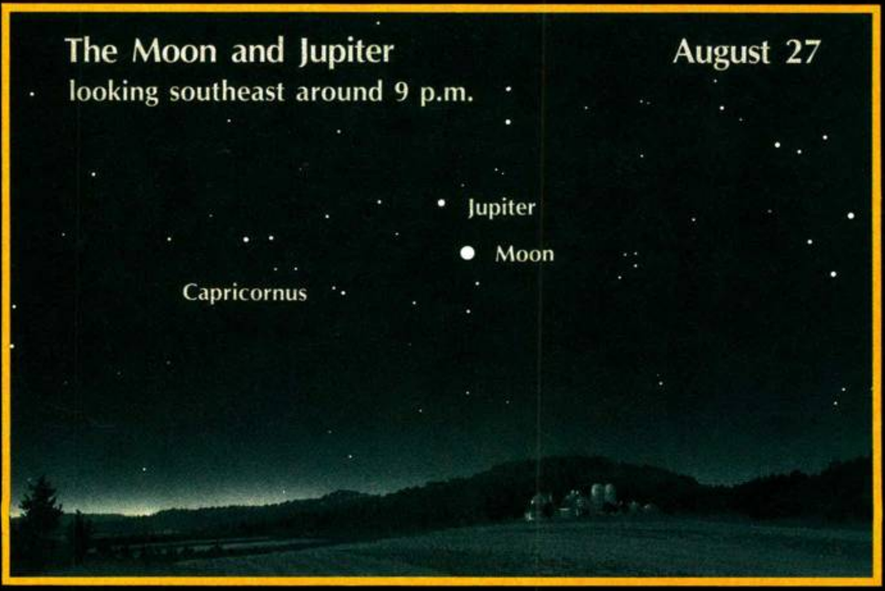
The Moon, Jupiter, and Venus high in the sky over Florida's palms. Photo by David L. Rights; 50mm f/8 lens, ½-second exposure.

August's Night Sky



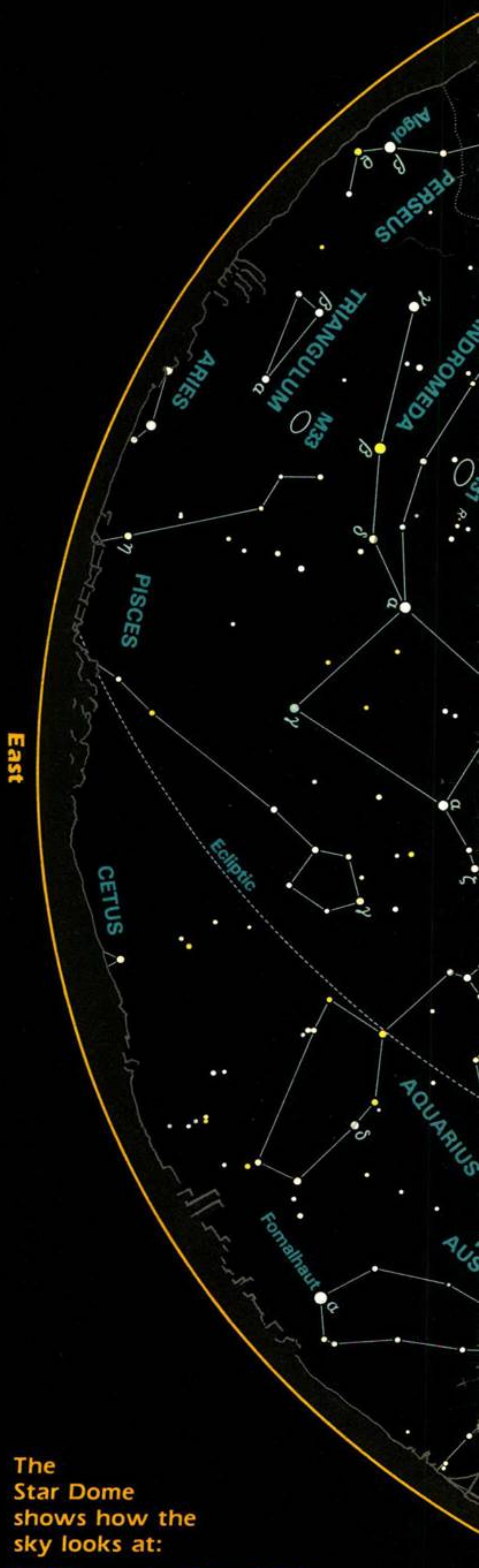
Last Quarter	New Moon	First Quarter	Full Moon
August 8	August 16	August 23	August 30
2:29 p.m. EDT	6:06 a.m. EDT	00:36 a.m. EDT	5:27 a.m. EDT

4th	Jupiter is at opposition today and will be at its brightest (magnitude −2.4) tomorrow at 7 p.m. EDT. This is the best time of year to see it as it moves from the morning into the evening sky.
7th	The Moon is farthest from Earth at 10:25 p.m. EDT: 251,106 miles, while Mercury is at its nearest to Earth: 55,800,000 miles.
8th	Last Quarter Moon occurs at 2:29 p.m. EDT.
10th	Mercury is at inferior conjunction with the Sun; it passes into the morning sky, but won't be visible until near the end of the month.
12th	Watch for the Perseid Meteors before dawn today.
13th	At 4 a.m. EDT, the Moon passes 5° north of Venus. Try photographing a fine grouping of the Moon, Venus, Castor, and Pollux (see diagram on page 42).
16th	New Moon is at 6:06 a.m. EDT.
20th	The Moon is closest to Earth at 00:21 a.m. EDT: 228,267 miles.
23rd	First Quarter Moon occurs 36 minutes after midnight EDT.
24th	The Moon passes 3° south of Uranus at 1 a.m. EDT today and moves to within 5° south of Neptune in the early morning sky tomorrow.
27th	Look for the nearly Full Moon near Jupiter tonight (see below).
28th	Mercury reaches greatest western elongation in the morning sky today, 18° from the Sun.
30th	Full Moon is at 5:27 a.m. EDT.



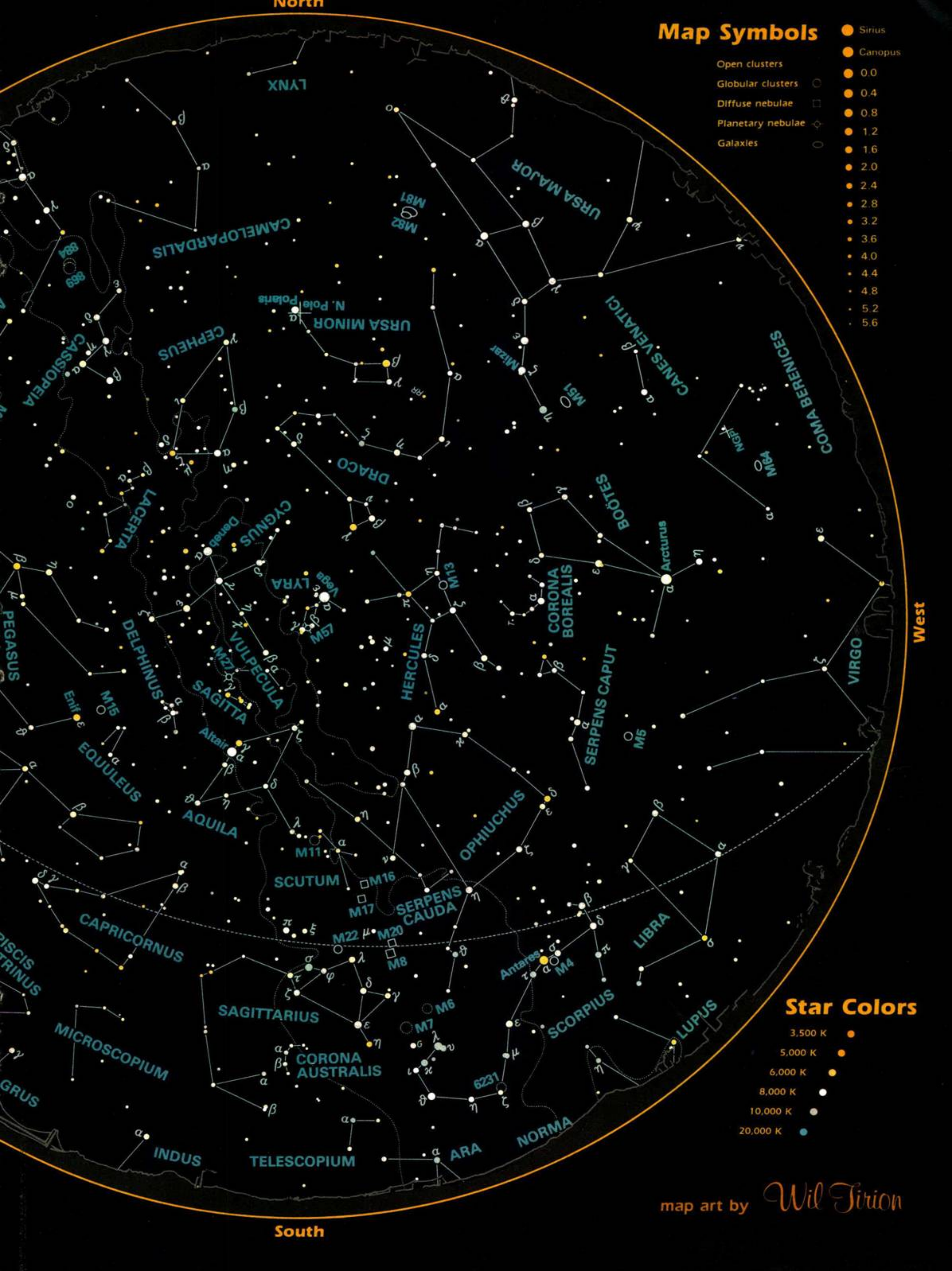
The Moon and Jupiter August 27

looking southeast around 9 p.m.



The
Star Dome
shows how the
sky looks at:

11:30 p.m. on August 1st
10:30 p.m. on August 15th
9:30 p.m. on August 31st


North
Map Symbols
Sirius
Canopus
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
4.0
4.4
4.8
5.2
5.6
LYNX
URSA MAJOR
CAMELOPARDALIS
M81
M82
884
869
N. Pole Polaris
URSA MINOR
CASSIOPEIA
CEPHEUS
Mizar
M51
CANES VENATICI
COMA BERENICES
NGP
M64
LACERTA
DRACO
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Deneb
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Arcturus
LYRA
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M57
M13
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SAGITTA
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M5
West
Enif
M15
EQUULEUS
Altair
AQUILA
OPHIUCHUS
M11
SCUTUM
M16
M17
SERPENS CAUDA
LIBRA
CAPRICORNUS
M22
M20
M8
Antares
M4
PISCIS AUSTRINUS
SAGITTARIUS
M6
M7
SCORPIUS
LUPUS
MICROSCOPIUM
CORONA AUSTRALIS
6231
GRUS
NORMA
INDUS
TELESCOPIUM
ARA
Star Colors
3,500 K
5,000 K
6,000 K
8,000 K
10,000 K
20,000 K
South

map art by Wil Tirion

can be seen by sharp eyes as two single points of light. And binoculars will give anyone a comfortable view of the two pairs.

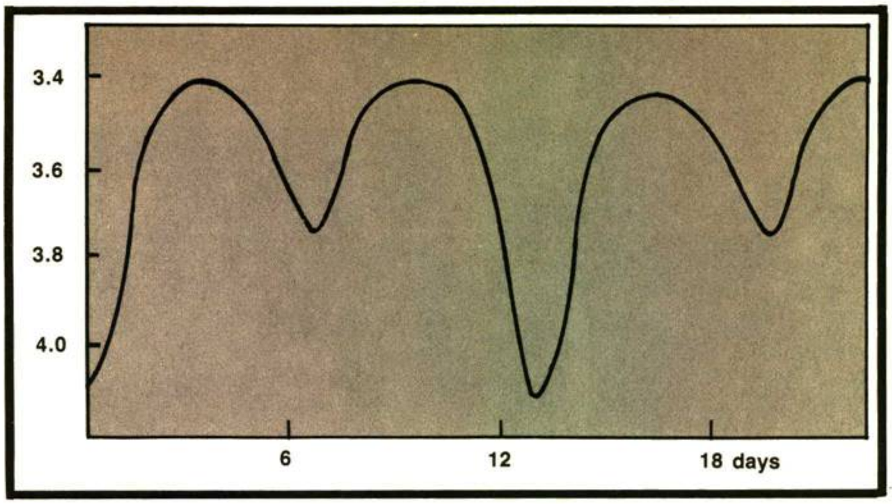
Lyra also has a bright naked-eye variable star, **Beta** (*β*) **Lyrae**. Beta is composed of two oblate stars connected by a tendril of matter flowing from the larger to the smaller. What makes it interesting is that the point of light we see is variable. If you sketched out Beta's light curve, you'd see an undulating line whose maxima always rise to magnitude 3.4 but whose minima alternately dip between magnitudes 3.8 and 4.1 (see diagram). The reasons for this are complex, but the two different minima are the result of the shape of the stars, the positions in their elliptical orbits, and the mutual eclipses of these unequally bright stars as they orbit in their cycle of just under 13 days. These light changes can best be spotted by comparing Beta to nearby Gamma Lyrae, which shines at magnitude 3.25.

As novice starwatchers soon learn, **Vega** is the brightest member of the **Summer Triangle**. The other two stars are **Deneb** in **Cygnus** the Swan and **Altair** in **Aquila** the Eagle. Although Deneb has a luminosity about 60,000 times greater than the Sun, it is about 100 times farther away than Altair and Vega, making it appear the dimmest of the three. This star is the tail — not the head — of the south-flying Swan.

The Swan's body is rich with numerous naked-eye stars and innumerable fainter ones in this bright section of the Milky Way. The **Cygnus Milky Way** may not be as impressive as that of Scutum or Sagittarius, but it is higher above the horizon for most of us, and therefore less dimmed by haze and light pollution.

The best month for evening viewing of Cygnus is probably September, but not so for Altair and its constellation **Aquila** the Eagle. Located much farther south than Vega and Deneb, Altair's prime evening visibility is much shorter for viewers around 40° north latitude. Observe Aquila now and use it as a guide to smaller constellations, such as **Scutum** the Shield and **Delphinus** the Dolphin (Aquila is poised flying roughly *from* Scutum *to* Delphinus). If you trace one line from Delphinus to Vega and another from Altair to Deneb, you find diminutive **Sagitta** the Arrow and larger but dimmer **Vulpecula** the Fox near the intersection of the lines.

Top: On October 25, 1983, Marty Murphy took this photo of the setting Sun flanked by bright Sun-dogs. She used a 28mm lens set at f/5.6, $^{1}/_{1000}$-second exposure, and ISO 64 film. Bottom: In this predawn photo, the light from a waning crescent Moon, Venus, and Jupiter are reflected in California's Salton Sea. Note the Lagoon Nebula above the overexposed Moon, and Scorpius on the right side of the frame. Photo by Jerry Schad; 35mm f/2 lens, 20-second exposure, 3M 1000 slide film.



Beta Lyrae's light curve — period 12.91 days.

It's worthwhile exploring Scutum for it contains the bright **Scutum Star Cloud** and one of the finest open clusters in the heavens — **M-11**, the "Wild Duck" Cluster (shown on the Star Dome map). It was discovered in 1681 by Gottfried Kirch. Binoculars will show you sixth-magnitude M-11 as a specially bright, hazy spot in the brilliance of the star cloud; were it not for this background, the cluster would be more easily detectable with the naked eye in very dark skies.

We have discussed reasons for staying up late on August *nights*, but August mornings are also good for viewing the "heliacal risings" of the heavens' brightest stars. The heliacal rising is literally the rising of an object with the Sun, but it has come to mean the first viewable appearance of an object before sunrise after a period when it was too near the Sun to see. The time of a star's heliacal rising varies according to latitude, but for most of our readers the Pleiades and Taurus should be clearly visible before dawn as August opens. On the other hand, Perseid watchers will have to look more carefully to spot Orion's brightest stars of Orion emerging from morning twilight.

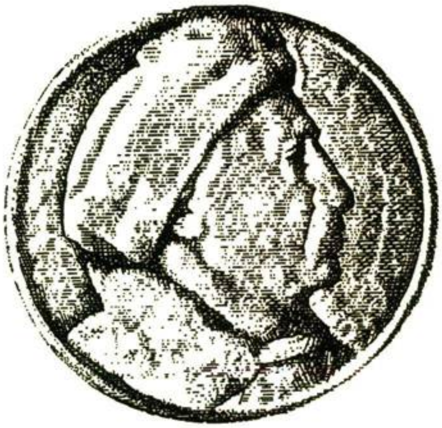
For many of us, August also presents the heliacal rising of **Sirius**, the brightest star. When is the first August morning that you can detect Sirius?

Skylore

Many constellations honor ancient — mostly mythical — heroes. Are there any that commemorate heroes of more modern times? The only such surviving constellation is Scutum, originally named Scutum Sobiescianum — Sobieski's Shield.

Scutum is pictured as the coat of arms of John (Jan) III Sobieski, perhaps the most famous of all leaders of Poland. He was elected king of the land — then called Poland-Lithuania — from 1674 until his death in 1696. The key event during his political and military career was a battle which took place on September 12, 1683 (fittingly, a month when Scutum is at its highest in the evening hours).

Sobieski had been fighting to protect his country from the invasions of the Turks; all of Western Christian Europe was well aware of the importance of this bulwark against the Turks. This crucial battle took place at the Kalenberg, where Sobieski defeated the Turks and prevented their march on Vienna. Hungary was freed. Sobieski had 20,000 Polish troops, but he personally led the decisive cavalry charge. In the years that followed, Sobieski attempted to extend his territory — presumably to its older boundaries — but was unsuccessful. Nevertheless, his great victory in 1683 won him acclaim as "the hero of all Christendom."



John (Jan) III Sobieski

Sobieski received another honor before his death, bestowed on him by the Danzig astronomer Hevelius: the creation of a constellation representing his shield. Author R.H. Allen writes that Hevelius gave Sobieski "a glowing tribute" in naming the new constellation; old star atlases show the Shield emblazoned with the sign of the Cross. According to Allen, the four stars bordering the shield — which some believe symbolize the dim constellation's pattern — supposedly represent the king's four sons.

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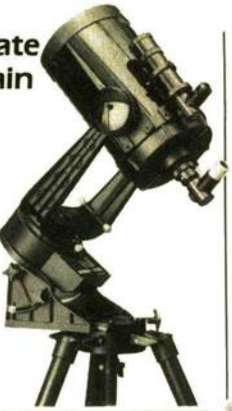

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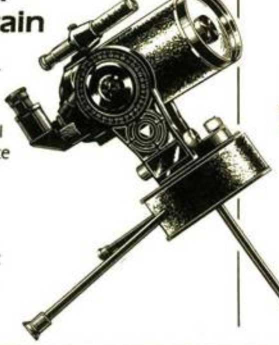

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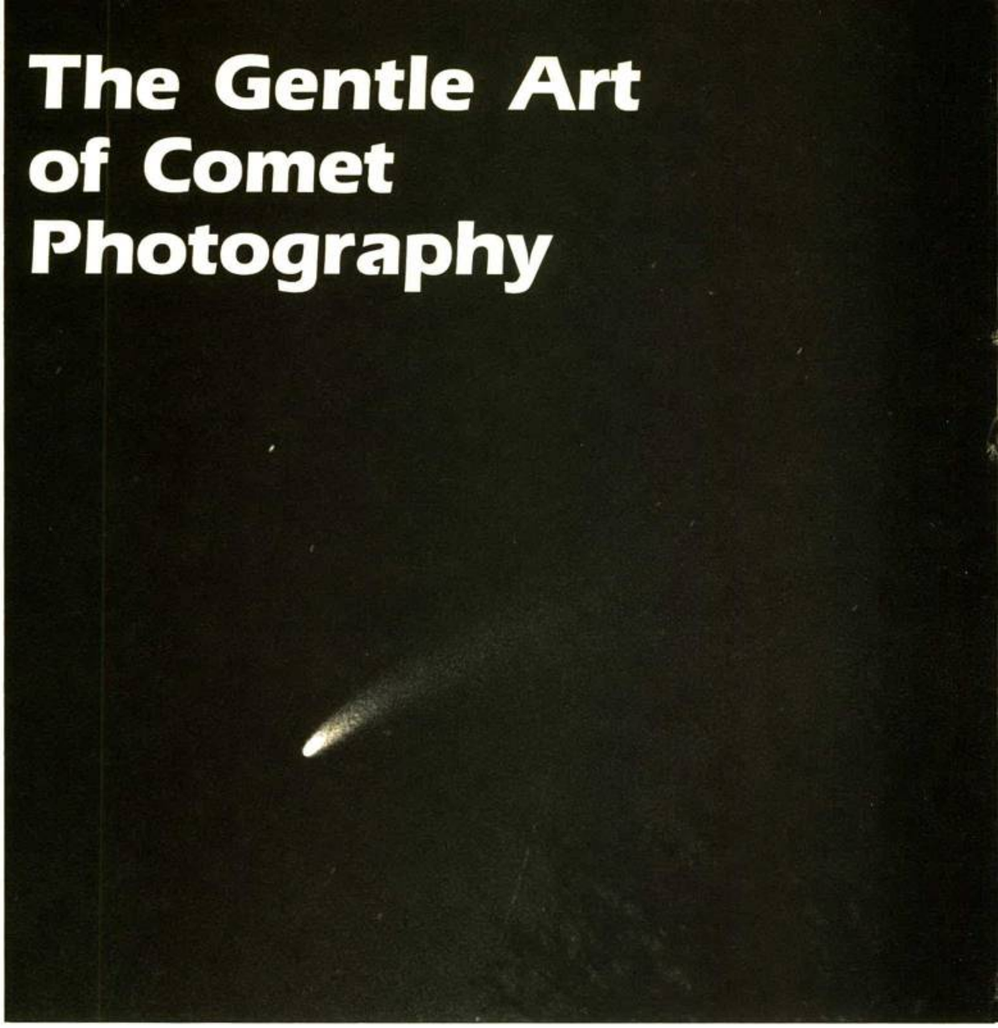


Opposite: Charles F. Capen piggybacked a 35mm camera fitted with a 135mm f/3.5 lens and an exposure of 30 minutes on Kodachrome X film to capture Comet Ikeya-Seki in 1965. Copyright © C.F. Capen Planetary Library and Historic Chart Archive. Above: Also using a 135mm lens — this time simply mounted on a tripod — E. Ken Owen exposed Tri-X film for just 15 seconds to record brilliant Comet Bennet in 1970.

Comets are the solar system's most graceful members. The bright fountainlike tail of 1970's Comet Bennett, the diffuse halo of 1983's IRAS-Araki-Alcock, the ball-like nucleus and thin tail of 1975's Kobayashi-Berger-Milon, the pinpoint nucleus and twisting tail of 1965's Ikeya-Seki, the stunningly-detailed, fan-shaped dust tail of 1976's West — each was a subtle, unique sight. Now Comet Halley, the grand-daddy of comets, is almost here. It's a sight you won't see again in your lifetime. Wouldn't it be nice to capture images of the comet to examine again and again on your slide projection screen?

With the gentle art of comet photography just about anyone can. But even with the right equipment, successful comet photography is no piece of cake. There are many circumstances that can interfere to mess up your photo during an exposure. Even after you've recorded the image safely on film and it has survived the hazards of photo processing, it's no mean feat to transfer it to paper to show your friends. Still, if you want to record photographic images of Halley — or future comets, for that matter — read on.

Stationary Cameras: Load, Focus, and Shoot

The simplest way to photograph comets requires only a sturdy tripod, a roll of film, and a camera able to take long exposures. Place the camera (loaded with film, of course) atop the tripod, aim it at the comet of your choice, focus the lens for infinity, and — using a cable release to prevent jarring the camera — make an exposure lasting anywhere from 20 seconds to 20 minutes.

Short exposures — those up to 30 seconds or so — will record bright stars and generally show a bright comet as a nonstellar ball with a fuzzy tail. Thanks to today's superb fast lenses and films, this type of comet photography is possible. It certainly means comet pictures no longer require a lot of fancy equipment.

Because of Earth's rotation, exposures longer than a minute will show trailed images of stars and comets, but you may find that the short exposures that produce point-like stars also produce pictures that are much too dark. While trails are pretty, they may not be what you had in mind.

Generally, to get enough light in a short exposure, you'll want to use a lens with an f/number smaller than f/2.8. In fact, the smaller the f/number, the better. F/1.4 is about as low as ordinary lenses go, and it's more than adequate. Lenses slower than f/4 tend to be photographically too slow (that is, they require an exposure that's too long) to record a comet's faint light during short exposures. Pick a lens in the 28mm (wide angle) to 50mm (normal) range, or else the sky coverage — the amount of sky in the photo — will be too small.

Color slide film is best for unguided exposures of the sky. Those that are fast and reliable include Ektachrome 400 and Fujichrome 400. Other fast slide films might work just as well, but it's best to shoot enough test exposures that the graininess of the ultra-fast films doesn't come as a surprise.

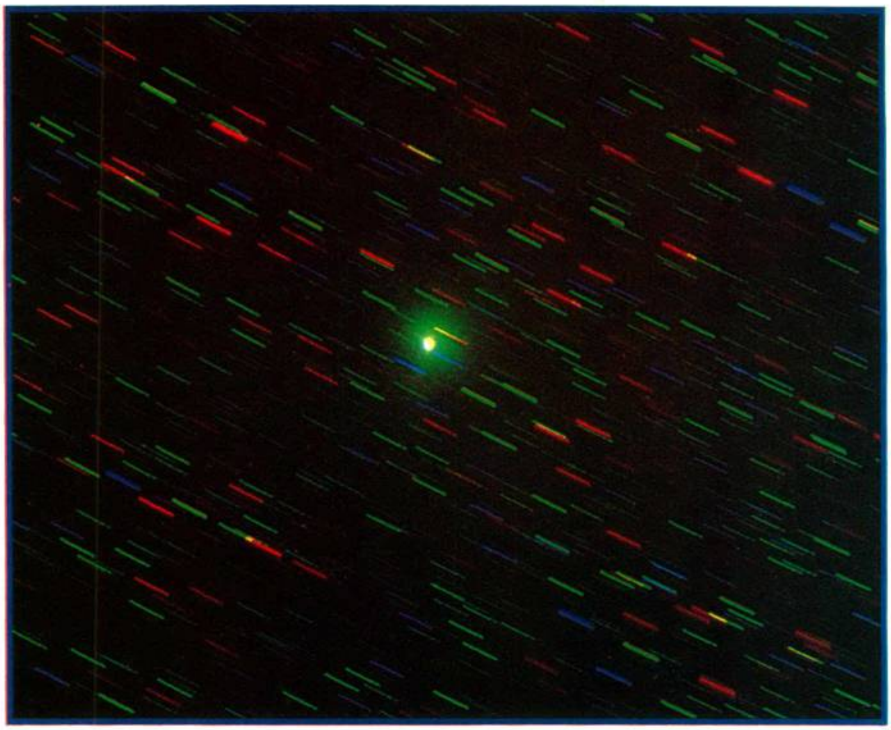
What's wrong with today's fast color print films? Nothing, really. VR-1000 yields excellent results if it's custom printed. But commercial film processors are set up to handle "people" shots taken in daylight and are mechanically developed. They print pictures of stars as if they were standard pictures of Aunt Ginny and the family. The result is a greenish-brown mess that doesn't look much like anything — certainly not the sparkling stars in a black sky that you wanted. Even if you order custom prints, most commercial print makers are unreliable when given a demanding task like printing the faint details of a comet's tail.

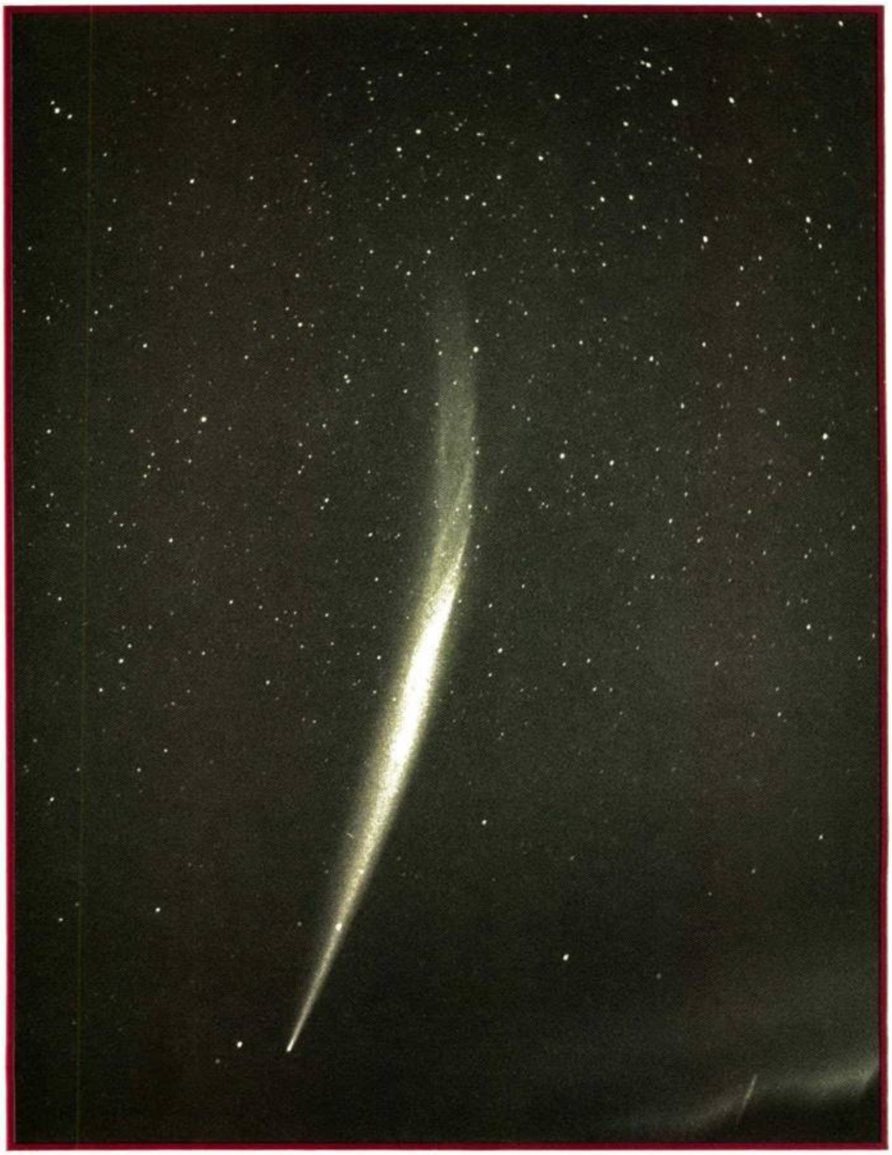
If you want prints, either shoot slides and have prints made from them or develop and print the photos yourself (see "A Darkroom for Astrophotography," September 1980 issue). If you do your own darkroom work, you will probably want to consider black and white pictures. Tri-X is still among the best fast, fine-grain black and white films, and it can be "pushed" to ISO 1600.

Simple Piggybacking

Although inherently more complicated than stationary camera photography,

Opposite: In 1976, Dennis Anderson piggybacked his 50mm f/2 lens and used High Speed Ektachrome film pushed to ISO 400 for this 2-minute exposure of Comet West. Right: Using a 4-inch astrographic camera with sheet film while guiding on the comet, Rev. Ronald Royer composited three separate exposures to produce this tricolor view of 1983's IRAS-Araki-Alcock. Below right: In 1965, Alfred Lilge made this exposure of Ikeya-Seki with a Kodak Duo-Six-Twenty f/3.5 roll film camera, Tri-X film and a 20-minute exposure.



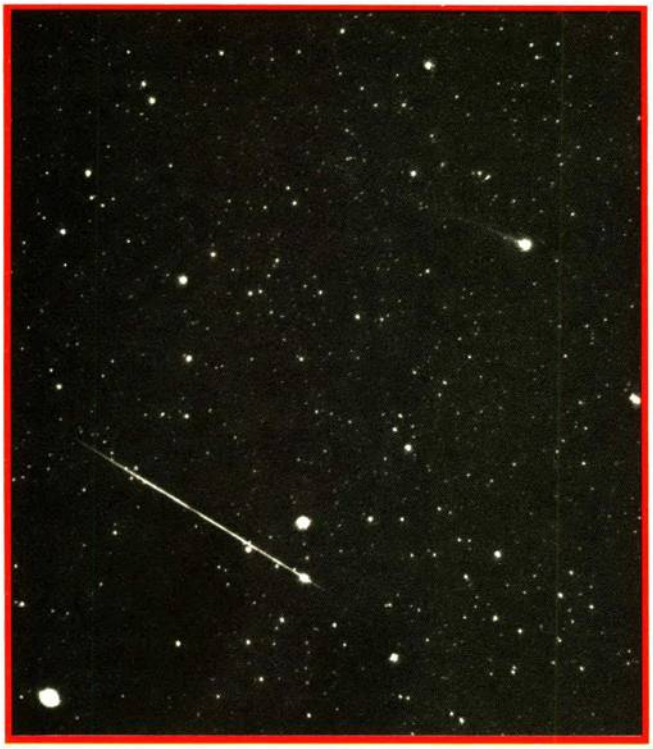


piggybacking with a standard or wide-angle lens can produce impressive results. Piggybacking means mounting the camera atop a telescope that's tracking the stars. This allows you to make much longer exposures of a comet. But because the telescope moves, piggybacking involves more things that can go awry during an exposure.

To make a piggyback photo, you'll need an equatorially-mounted telescope. Load the camera with fast film, securely fasten the camera atop the scope (an adjustable clamp with a tripod screw, available in camera stores, is a big help), attach a cable release, set the exposure on "b" or "t," and set the focus for infinity. Now comes the difficult part: you must align the telescope with the north celestial pole — the spot around which all the stars appear to rotate. To do this adequately for wide-angle sky photography, aim the scope's polar axis at a point ¾° from Polaris in the direction of the Big Dipper's handle. This coarse polar alignment should suffice for short piggyback exposures if you use a wide-angle or standard lens — say, 28mm to 50mm. (For details on precision polar alignment, see "Easy Steps to Perfect Polar Alignment," August 1982 issue, and "How to Use a Polefinder," May 1985 issue.)

With the mount aligned, insert an eyepiece into the telescope, center on a bright star, and turn on the telescope's drive. If you've done a good job polar aligning the scope, the star should stay reasonably still relative to the field of view for about half an hour of tracking.

After you've gone through all this rigamarole, you're ready to take a piggyback photo. Compose the photo to include as much of the comet as you can. If you center the head of the comet in the camera's field, you may get less of the tail than you will if you aim about halfway down the tail. At the same time, locate any suitably bright star and center it in the telescope eyepiece. This allows you to monitor the telescope's progress as the exposure runs so that you can stop the exposure if haze rolls over the area, a plane flies through the field, the drive stops, or something else fouls up. After getting the camera aimed and locating a monitor star, start the telescope's drive and begin the exposure by pressing and locking the cable release.



Opposite bottom: Claude Nicollier used moonlight to his advantage for this short, unguided exposure of Comet Bennett rising over the French Pyrenees in 1970. Opposite top left: An unguided piggyback exposure made in 1975 shows Comet Kobayaski-Berger-Milon and a brilliant meteor. Larry King made this photo using a 58mm f/1.4 lens, a 7-minute exposure, and Tri-X film pushed to ISO 800. Opposite top right: In 1976, Pat Michaud shot "through the scope" and recorded this 6-minute exposure of Comet West with a 6-inch f/3 Newtonian.

Since the telescope is now tracking — a giant step beyond the camera-on-a-tripod approach — you can expose the film for as long as the telescope seems to be properly tracking on the stars. Exposures ranging from 30 seconds to half an hour should show considerable comet detail, depending on the camera lens and film you're using and the comet you're shooting. Since you aren't limited to the fastest films you can find, you'll get sharper, less grainy pictures. Although long exposures may create trailed stars due to imperfect polar alignment or fluctuations in the telescope drive, you'll almost certainly record more stars — and comets — than you would have without piggybacking.

By piggybacking you also have somewhat more freedom in lens selection. The standard, reliable choices still lie between 28mm and 70mm focal length. As you increase the focal length, the amount of sky in the frame decreases and tracking becomes more critical. For example, if you piggyback a telephoto lens, you may find the resulting images are flawed in one way or another because the drive and alignment simply aren't precise enough to follow the stars to perfection.

The Pitfalls of Guided Photography

Guided astrophotography — precisely following the stars — opens new possibilities for photographing faint objects like comets. It allows you to run long time exposures, use any kind of film (fast or slow), and to photograph through any telescope/camera system desired.

No longer are you limited to relatively short focal length cameras or fast grainy films. Now you can use fine-grain ISO 64 color film or high resolution, high contrast black and white Technical Pan 2415; you can attach a 200mm lens for a 40-minute exposure or you can mount a 400mm lens atop your telescope and shoot comet closeups. But there's a catch: while you're unbounded in theory, in practice you must learn the tricky, frustrating art of guiding.

The easiest way to perform guided astrophotography is to mount a camera on top of an equatorial telescope and use the main scope itself as a guide telescope while photographing. Basically, you set up as you would for unguided piggyback photography: polar align, mount the camera, secure the cable release, compose your shot through the camera's viewfinder, and find a monitor star in the telescope's eyepiece. But now you don't let the telescope track unattended — you'll watch a star image through the telescope and keep the scope pointed at that star throughout the exposure. To do this, you'll need an illuminated reticle eyepiece and a drive corrector with slow motion controls so that you can move the telescope slightly in any direction. The monitor star now serves as your celestial reference against the "crosshair" in the eyepiece, and the slow motion controls let you correct the errors you see in the telescope's drive and polar alignment. After you get the telescope operating, center a guide star and start the exposure; keep the guide star precisely centered on the crosshairs during the entire exposure (see "Guiding," December 1980 issue).

Astrophotography in ASTRONOMY

The following articles are informative sources for beginning or intermediate astrophotographers:

"A Darkroom for Astrophotography," September 1980.
"An Inexpensive Roll Film Holder for Schmidt Cameras," February 1984.
"Astrophotography: A Novice's View," June 1983.
"Astrophotography — With Camera Only!," June 1978.
"Easy Steps to Perfect Polar Alignment," August 1982.
"Exposure in Astrophotography," January 1985.
"Getting the Most from Slide Films," January 1983.
"Guiding," December 1980.
"High Resolution Astrophotography," November 1979.
"How Much Sky Can My Camera Capture?," June 1982.
"How to Reduce Tracking Error," February 1982.
"How to Save Money on Astrophotography," October 1981.
"Making an Astrophotographic Mosaic," March 1985.
"Making Astroprints," January 1981.
"Off-Axis Guiding: Pain or Panacea," February 1983.
"Piggybacking — Without a Drive," April 1979.
"Processing Your Astronegatives," November 1980.
"Short Focus Photography," September 1983.
"Successful Schmidt Camera Photography," December 1984.
"The 2415 Revolution," March 1982.
"Wide-Field Sky Photography," January 1980.

Guiding is difficult. It requires that everything works perfectly, and often things don't. Unfortunately, the only way to become adept at guiding and producing good photographs is through practice — which means you'll have to suffer through making a lot of bad pictures in the process if you haven't done guided photography before.

Shooting through the Scope

The most difficult way to photograph comets — but the only method which produces detailed, close-up portraits — is through-the-telescope photography. Here, the telescope's optics themselves replace the camera lens. This requires you to guide with high precision using either an off-axis guider or a separate guide telescope mounted on top of the telescope/camera. In addition to the equipment previously mentioned (equatorial-mounted telescope, drive corrector, camera loaded with film and equipped with cable release, and guiding eyepiece), you'll also need an adapter to mount your camera at the telescope's focus and counterweights to balance the added weight of the camera or guidescope.

A separate guidescope can be conveniently pointed a few degrees away from the comet, enabling easy selection of bright guide stars. It can also be a nuisance, however; if the guidescope moves slightly in relation to the telescope during an exposure, images will be trailed no matter how perfectly you have guided.

An off-axis guider fits between the camera/telescope adapter and the camera. It uses a small prism to deflect light from a guide star into the guide eyepiece. This eliminates the flexure problem because even if the telescope sags, you guide directly on the image, but it severely limits guide star selection (see "Off-Axis Guiding: Pain or Panacea?," February 1983 issue).

Because of the long focal length of most telescopes, a photo taken with one is more likely to show all your guiding errors. Even a big telephoto lens will have a 500mm focal length; your telescope may have 2000mm or more, so the tolerance for error is significantly less and small errors in guiding show more easily.

The gentle art of comet photography isn't easy — but it's not impossible, either. Those big, sophisticated astrophotography rigs demand patience, technical skill, and experimentation to work right. But the simplest camera-on-tripod shots take almost no effort. Somewhere along the line between shooting color slides with camera and tripod and shooting hypered TP 2415 through a 16-inch Newtonian you'll find a comfortable spot. Maybe piggyback is right for you. Practice taking photos now — before Comet Halley brightens — and you'll become good enough to capture your own, once-in-a-lifetime images of Halley's Comet.

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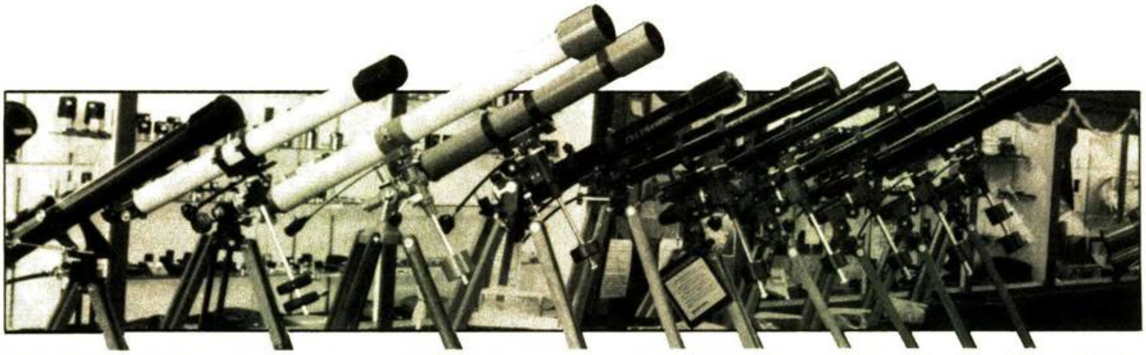

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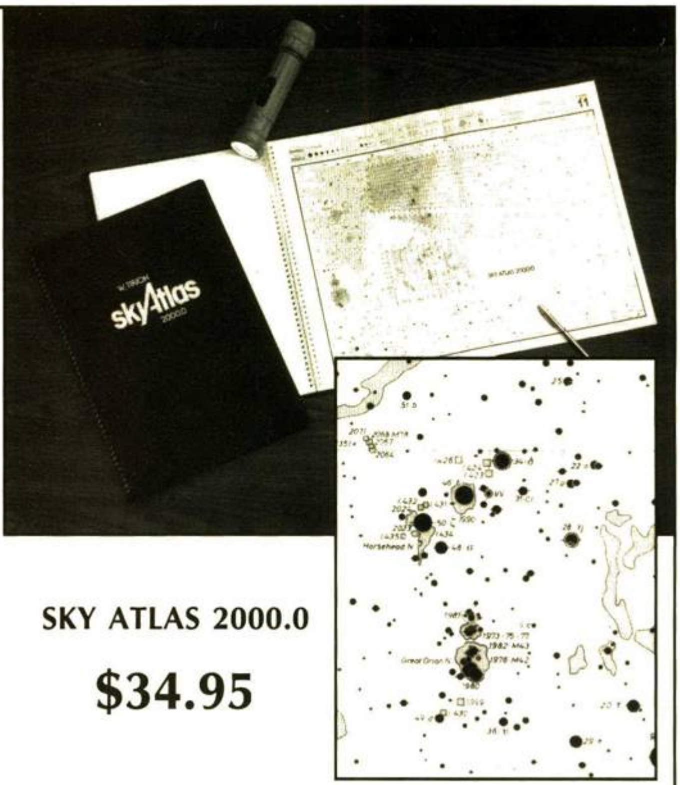

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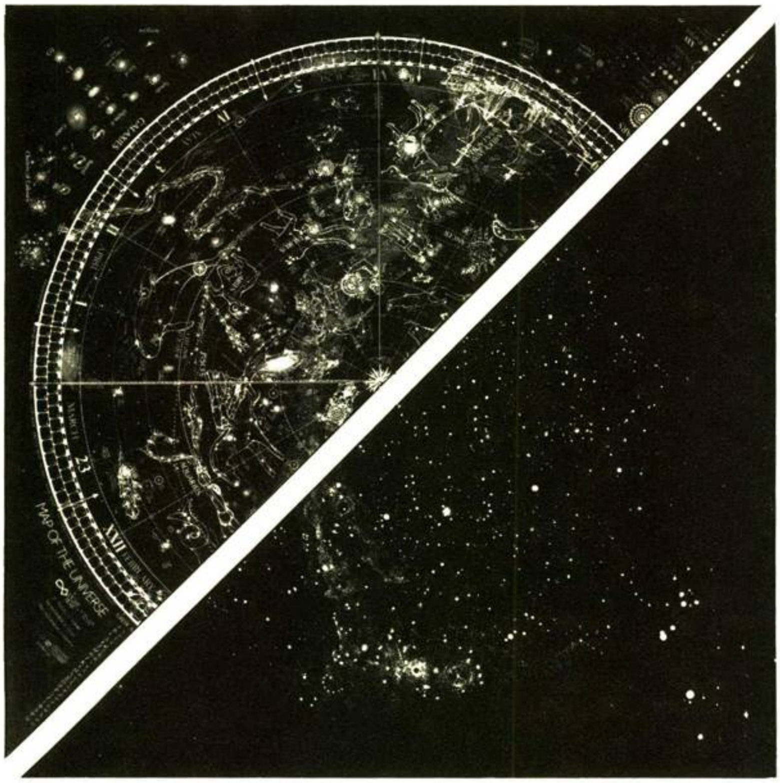

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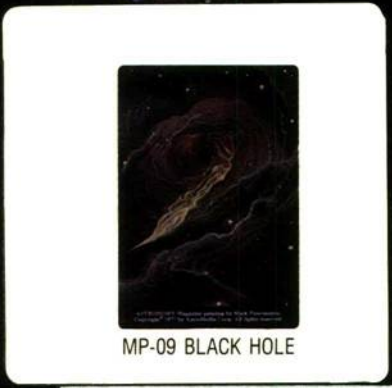

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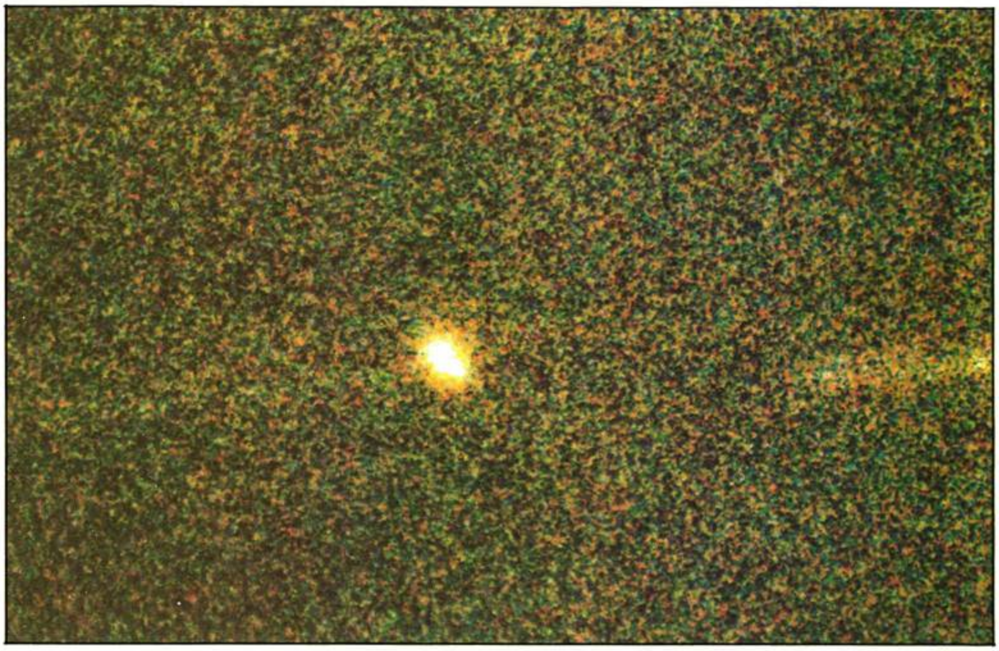
ASTRO NEWS



Bill Katz

An Observable Gamma-Ray Burster?

On March 18, 1985 members of the North York Astronomical Association (NYAA) of Toronto photographed a bright flash on the Aries-Perseus border, tentatively identified as a gamma-ray burster. (See "Chasing The Ogre," ASTRONOMY, April 1985.) The Canadian group has detected 22 such flashes visually during the past year, but this is the first such photograph obtained.

The event occurred at 9:42 p.m. EST (1h42m UT on the 19th) and was observed from Og's Bog Observatory, Schomberg, Ontario. The −1 magnitude yellowish flash lasted about a quarter of a second. Its position was 3h13.6m +32°15′ (epoch 2000.0), approximately 4′ west of the sixth-magnitude star SAO 56308 (HR 978) in Perseus and just east of ninth-magnitude stars SAO 56258 and SAO 56260.

Taken on ISO 400 Fuji film, the photo reveals a slightly flattened oval shaped like the image of a fixed star. The greenish grains on the fringe of the image are artifacts due to oversaturation of the central image. There is no evidence of motion or a halo which might be expected with a bright point meteor.

A densitometer analysis by Ron Lyons of David Dunlap Observatory shows the image resembles similarly-colored star trails in terms of color density and distribution. According to Alex Fullerton of the University of Toronto, the object's position falls within the error box of a known gamma-ray burster (published in Klebesdal *et al.*, *Astrophysical Journal Letters*, volume 259, page L51, 1982).

If further work confirms the flash's identity as a gamma-ray burster, NYAA members will have obtained the first visual observations of a burst in progress, pinpointing the brightest and most frequent optical burster known. The photograph may be the only "live" image of such a burst — previous images existing only on archival survey plates.

The duration, light curve, and frequency of the Ogre — as the NYAA has dubbed the object — are similar to those of the only confirmed optical counterpart of a gamma-ray burster, which is located in the Large Magellanic Cloud. The NYAA observed two kinds of events: zero to first-magnitude white or bluish-white flashes lasting less than a quarter second, and third-magnitude orange flashes lasting up to one second. Both display abrupt onset and slow brightness decay. The visual events occur randomly on the average of once every four days, although several dim flashes have been observed within a span of minutes or hours, and at least two reported events involved two or more flashes within seconds.

The NYAA photographers included Bill Katz, Dan Driscoll, Richard Rokosz, Richard McWatters, Joe Adair, and John Zehethofer. Mark Zalcik of Edmonton photographed in cooperation with the association. Ken Tapping of the Herzberg Institute in Ottawa first noticed the importance of the observations and encouraged the group's efforts, and Marshall McCall of the University of Toronto helped in photographic searches and analysis. *Bill Katz.*

Countdown to Halley

Comet Halley's last visit caused such a stir in the astronomical community that the backlog of data took 20 years to analyze. The situation was worsened by poor cooperation between observatories, bureaucratic red tape, and insufficient staffing and funding for analyzing the data. These unfortunate factors created a bottleneck for astronomers, hampering their study of this famous celestial wanderer.

Today, astronomers are more organized than they were 76 years ago. The International Halley Watch (IHW) was established in 1982 to coordinate observers, encourage cooperation, and facilitate the unrestricted flow of data. While Halley's Comet is here, the IHW will gather information from observatories and backyard sky gazers on the size, shape, brightness, spectrum, nucleus, tail, and coma of the comet. By pooling this data, they hope to establish a better picture of the inner workings of comets in general and specifics about Comet Halley.

The complex job of collecting this information will take place at the Jet Propulsion Laboratory facilities in Pasadena, California, and at the Remeis Observatory in Bamburg, West Germany. Astrometric observations have already determined a detailed "flight path" for the comet. As Halley draws nearer, IHW astronomers will be looking at nongravitational forces that affect the comet's motion by acting as rocket jets of gaseous matter shooting outward from the nucleus. IHW observers will also examine the comet's dust tail and the expansive plasma tail. Cameras stationed in both northern and southern hemispheres will record the comet for use as guidance information by the four spacecraft as they approach "final encounter."

Astronomers also hope to answer a number of long-standing questions about the nature and formation of comets. Recent infrared observations have allowed astronomers to directly observe cometary ices in their data. As Halley approaches, infrared and near-infrared observations of this type will permit astronomers to study how warmed ices outgas from the comet's nucleus. These observations can then be applied to determine the atmospheres of Titan, Uranus, and Neptune, as well as here on Earth.

Many astronomers engaged in photometric and polarimetric research will follow standardized programs to ensure a supply of homogeneous data. The first of these involves filter photometry done with a variety of different aperture diaphragms and interference filters provided by the IHW. The data will be sifted to extract fundamental clues to the conditions in which comets form, the nature of interstellar gas, the early stages of chemical evolution, and — hopefully — the very origins of life.

When Halley's Comet becomes bright early in January 1986, IHW stations across the globe will conduct filter photometry in hopes of catching a spasmodic outburst — violent outgassing — in the coma. A typical outburst lasts but a few days; global coverage would provide the first in-depth study of such an event. Astronomers working independently will also conduct photometric analyses of Halley's surface brightness, spectral features, thermal anomalies, and sporadic phenomena. Their studies should lead to a flood of informative literature beginning in mid-1986.

Since the comet follows a very predictable orbit, astronomers will attempt to measure the size of its nucleus using radar. Halley's great

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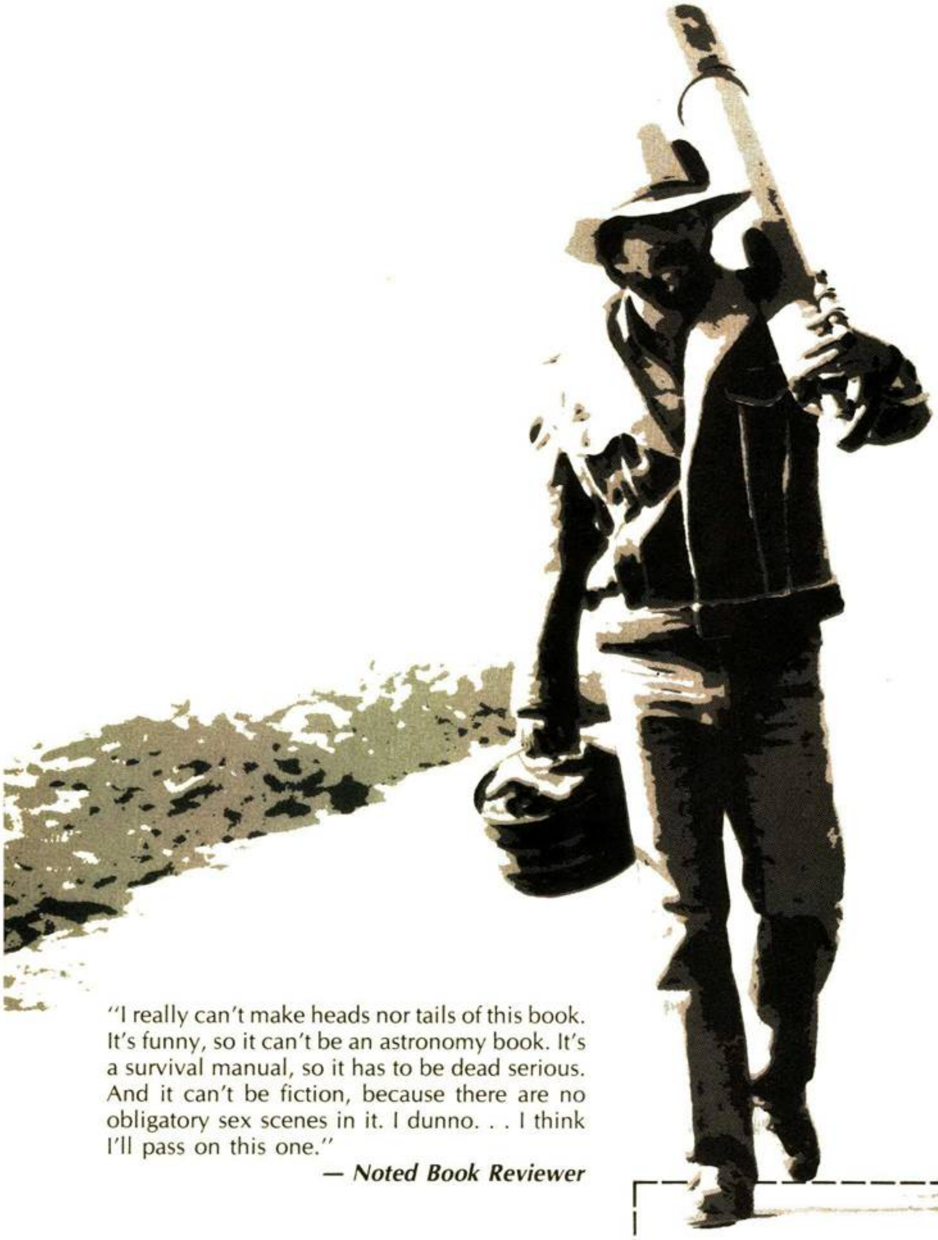

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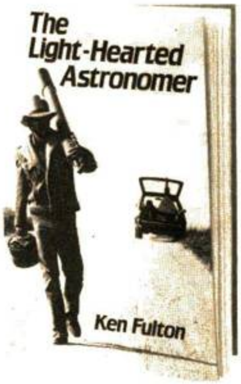

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distance and tiny nucleus make this exceedingly difficult. Other radio techniques will scan spectral lines at radio wavelengths and should provide information on the composition of the nucleus and surrounding coma.

As Comet Halley approaches, astronomers the world over are banding together, sharing equipment and knowledge. The immense amount of data they gather should produce one of the most fascinating studies in the annals of science. *Aldo G. Rabaiotti.*

Supernova Found in Quasar

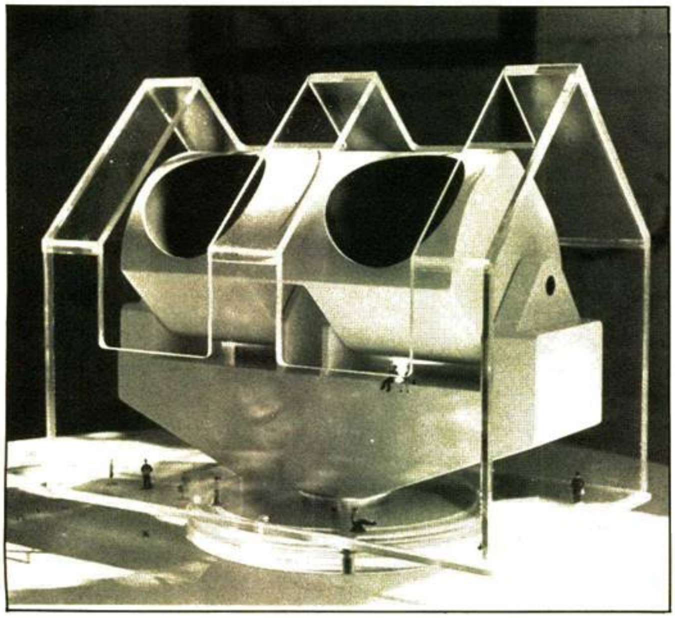
In a paper published in *Astrophysical Journal,* Canadian astronomers Bruce Campbell of the Dominion Astrophysical Observatory, Carol Christian of the Canada-France-Hawaii Telescope Corporation, Chris Pritchet of the University of Victoria, and Paul Hickson of the University of British Columbia reported on their discovery of a probable supernova in a galaxy containing a quasar. This discovery apparently confirms that quasars are the most distant objects in the universe.

The astronomers' study is based on two photographs. The first, taken by the group in May 1983, shows a starlike image 2.6 arc-seconds away from the quasar 1059+730, located on the Ursa Major-Draco border. (The quasar is surrounded by a faint halo of nebulosity, which astronomers assume is a galaxy centered on the quasar.) A second photo, taken in July 1984, shows no starlike image near the quasar.

Because the two photographs were made using different cameras and telescopes, the astronomers had to carefully process the images to be sure the supernova was not simply a photographic defect. It wasn't. The May 1983 image appeared real and had the characteristics of a supernova. The astronomers later found that the star wasn't visible on exposures of the same area of sky made in January 1981, December 1981, and May 1982.

The group is uncertain whether or not the supernova was at peak brightness when observed, casting some doubt on its intrinsic brightness and therefore its distance, but they believe it lies about 300 megaparsecs away. The quasar's distance, determined by the redshift in its spectrum, is also about 300 megaparsecs.

During the last few years, astronomers have amassed evidence that quasars are not isolated objects; rather, they seem to be the energetic centers of otherwise normal spiral galaxies. Although the faint, fuzzy patches of light surrounding quasars showed a spectrum characteristic of starlight, no individual star associated with a quasar has ever been observed up until now. Although this discovery confirms that quasars are very distant, energetic objects, it does not explain the mechanism by which quasars generate energy. The best hypothesis put forth by most astronomers remains the same: quasars are powered by supermassive black holes — "central engines" buried deep within their cores.



Late in April, Ohio State University and the University of Arizona announced plans to build the world's largest optical-infrared telescope on Mt. Graham in Arizona. This instrument may feature two 8-meter mirrors, making it 2.5 times as powerful as California's 5-meter Hale telescope. The new infrared telescope will take over six years to build and cost the two universities over $30 million.

Spin-Cast Mirrors May Cut Costs

For the first time, an astronomer has successfully devised a new way to cast glass telescope mirrors. The technique, called spin-casting, could revolutionize the way future optical telescopes are constructed and drastically reduce their cost. Roger Angel, an astronomer at the University of Arizona, created the experimental mirror which has a 6-foot diameter and an f/ratio of 1. By drastically reducing the cost of producing large optical mirrors, Angel's work may lead to a new generation of 8-meter class telescopes.

In spin-casting, the curved face of the mirror is shaped by centrifugal force. To make a mirror blank, solid blocks of glass are placed in a mold in a furnace mounted on a turntable. While it turns, the furnace melts the glass which then flows in the mold. The spin-coating technique eliminates much of the time and expense of grinding the blank.

Angel's work is part of a larger effort to investigate new technologies that can be applied to very large optical telescopes planned for the future. Casting the 6-foot test mirror is just one step in a series of trials that the Arizona astronomer hopes will result in the production of lightweight, inexpensive mirrors measuring about 26 feet in diameter. Traditionally, large telescope mirrors have been thick and heavy, and manufacturers have resorted to exotic and expensive types of glass to minimize distortion due to temperature changes. A notable exception is the 200-inch (17-foot) mirror for the Mount Palomar telescope which was cast from a glass similar to Pyrex 50 years ago. The thermal problems involved in developing this large mirror were solved by giving the back of the mirror a rib structure. This not only minimized temperature changes but also reduced weight.

Angel relied on advances in refractory materials, electronic control systems, and heating technology to revive and improve the art that produced the 200-inch mirror. Modern refractory materials allow for lightweight molds and furnaces. In Angel's new technique, molten glass is not poured into a mold as it was for the 200-inch Mount Palomar mirror, but solid glass is melted in the mold. Hexagonal boxes in the mold give the glass a honeycomb rib structure which makes the mirror both light and strong.

Old Stars for New

One of the major problems facing astronomers is that stellar evolution proceeds so slowly that the sky hardly changes in a human lifetime. Consequently, astronomers are very interested in ancient astronomical records — notably, those of the Chinese. However, one of the oldest collections of astronomical data — the star catalogue contained in Ptolemy's *Almagest* — is often regarded as hopelessly unreliable since it contains apparently inexplicable errors and omissions. A paper published in the *Monthly Notices* of the Royal Astronomical Society by Keith Hertzog, however, argues that these very omissions may provide valuable information to help unravel some of the complex processes of stellar evolution.

The star catalogue in the *Almagest* was likely compiled by Hipparcos of Nicaea around 130 B.C. Hipparcos recognized the effect of precession (the wobbling of the Earth's rotation axis) by comparing his observations to those made by earlier astronomers. His realization that an accurate list of star positions and brightnesses could be of use to future astronomers led Hipparcos to compile the catalogue for posterity. In view of the long-term nature of the project, it seems certain that Hipparcos would have tried to make his documentation as reliable as possible; although some errors may have been introduced by repeated copying, the data should be basically sound. If so, the catalogue may contain evidence for variability over a 2,000-year base line between 130 B.C. and the present.

The catalogue might also help today's astronomers in resolving the nature of a supernova seen from Earth in 1006 A.D. Some believe it was a Type II supernova — those

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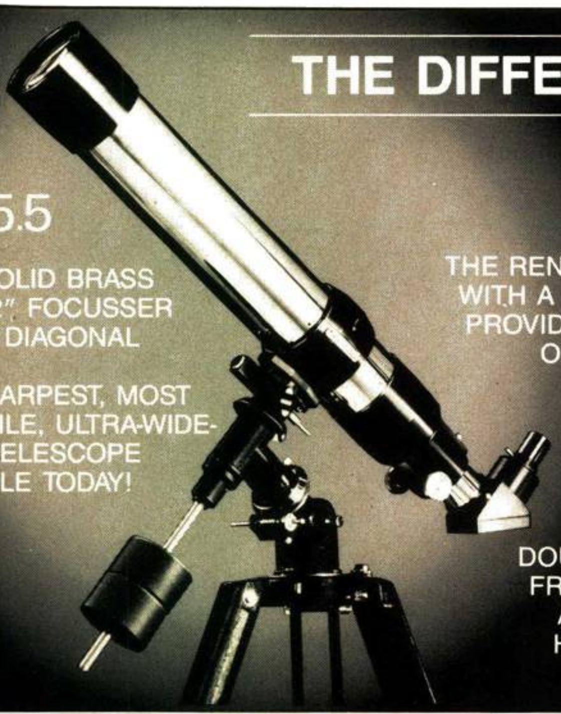

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ASTRO NEWS

caused by the collapse of a red giant star; others think it was a Type I supernova — the final stage in the evolution of a close binary system. Hipparcos' catalogue covers the region of sky in Lupus where the 1006 A.D. supernova occurred, but shows only stars visible today. This implies that the star which produced the 1006 supernova was too faint to include in the catalogue, ruling out a Type II supernova, which would almost certainly have been brighter than magnitude 4.5.

Hertzog follows up his argument by noting that, with practice, naked-eye estimates of stellar magnitudes are quite accurate. Accordingly, where major discrepancies exist between magnitudes in the *Almagest* and currently accepted values, these may reflect real changes and not just transcription errors. In particular, several of the missing bright stars are of spectral type Be. These stars occasionally eject a massive shell of gaseous material which obscures their light, dramatically dimming them for irregular periods. The omission of these Be stars from the catalogue may mean that 2,000 years ago they were less conspicuous than today. If so, perhaps other oddities in the *Almagest* contain valuable information on long-term stellar variability. *J.K. Davies.*

ASTRO CALENDAR

July 15-August 2
Astronomy Institute for Pre-College Teachers, The University of Texas at Austin, Austin, Texas. Contact: Mary Kay Hemenway, College of Natural Sciences, The University of Texas at Austin, Astronomy Department, RLM 15.308, Austin, TX 78712. Phone (512) 471-4461 ext. 307.

August 9-11
STARFEST '85, The River Place Campground, Mount Forest, Ontario, Canada. Contact: Andreas Gada, 145 St. George St., Apt. 701, Toronto, Ontario, Canada M5R 2M1.

August 10-24
Croydon Astronomical Society 5th Annual Astro-Camp, Hindleap Warren, Forest Row, Sussex, England. Contact: Norman Fisher, 5 Dagmar Rd., South Norwood, London, England SE25 6HZ. Phone 01-771-0477.

August 15-16
The New Vision of the Universe (international astronomical symposium), Medellin, Colombia. Contact: Kevin P. Marshall, ACAFA, Calle 56, N°47-23, Apto. 601, Medellin, Colombia, South America.

August 15-17
Mountain States Star Party, Monte Cristo Campground (40 miles east of Ogden), Utah. Contact: Bob Tillotson, 2336 W. 5650 South, Roy, UT 84067, phone (801) 773-8106 or Dennis Donnelly, 56 Tulane, Pocatello, ID 83201, phone (208) 232-4060.

August 15-19
Second Annual Mt. Kobau Star Party, Okanagan Valley, British Columbia, Canada. Contact: Peter Kuzel, 4100 25th Ave., Vernon, British Columbia, Canada V1T 1P4.

August 16-18
2nd Annual Mountain Astronomers Rendezvous and Star Party, Dinosaur National Monument, Northwest Colorado. Contact: Stefan C. Perrine, 7510 King St., Westminster, CO 80030.

August 17
Stellafane, Springfield, Vermont. Contact: Dennis di Cicco, 60 Victoria Rd., Sudbury, MA 01776.

September 13-15
Astrofest, Chicago, Illinois. Contact: Astrofest, P.O. Box 596-A, Tinley Park, IL 60477. Phone Jon Nehls at (312) 385-3473 or John Phelps at (312) 532-2968.

September 13-15
"The Conjunction" sponsored by the Connecticut River Valley Amateur Astronomers, Northfield Mountain Environmental Center, Northfield, Massachusetts. Contact: Jack Megas, 311 Surrey Rd., Springfield, MA 01118.

September 28
Ohio Turnpike Astronomers Association Convention, The University of Akron, Akron, Ohio. Contact: Philip Hegenderfer, 5070 Manchester Rd., Akron, OH 44319. Phone (216) 644-0230.

October 5
Herstmonceux 85, 5th Annual Convention of the British Federation of Astronomical Societies, Herstmonceux Castle, East Sussex, England. Contact: Ken Marcus, 5 Cedars Gardens, Brighton, East Sussex, England BN1 6YD.

October 5
Astro-Assembly, Seagrave Memorial Observatory, North Scituate, Rhode Island. For information, send SASE to: Charles J. Lord Jr., 126 Fair St., New Bedford, MA 02740.

October 5
Telescope Users Clinic, Whittier College, Whittier, California. Contact: Bob Ferguson, Western Observatorium, 13215 E. Penn St., Suite 411, Whittier, CA 90602. Phone (818) 795-4181.

October 10-12
Joint Meeting of the Rocky Mountain Planetarium Society and the Pacific Planetarium Association, Hansen Planetarium, Salt Lake City, Utah. For information, send SASE to: RMPA Meeting, P.O. Box 3023, Boulder, CO 80307.

October 17-20
Okie-Tex Star Party, sponsored by the Oklahoma City Astronomy Club, Lake Murray, Oklahoma. Contact: Joe Pearson, 700 Teal Pl., Edmond, OK 73034.

November 7-8
SPACE STATION: Gateway to Space Manufacturing and Services, Orlando, Florida. Contact: Anne Phelan, *Space Business News*, 1401 Wilson Blvd., Suite 910, Arlington, VA 22209. Phone (703) 528-1244 or (800) 424-2908.

November 9-10
Deep South Regional Stargaze, Percy Quin State Park, McComb, Mississippi. Contact: Frank W. Loflin II, ALCOR, Jackson Astronomical Association, 280 W. Lorenz Blvd., Jackson, MS 39213. Phone (601) 982-2388 days or (601) 856-3636 evenings.

Meeting notices to appear in AstroCalendar must be submitted at least four months in advance of the meeting date. Most organizations appreciate your enclosing a long (business-size) self-addressed, stamped envelope along with your request for information.

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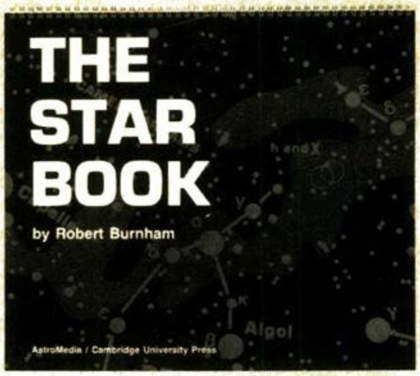

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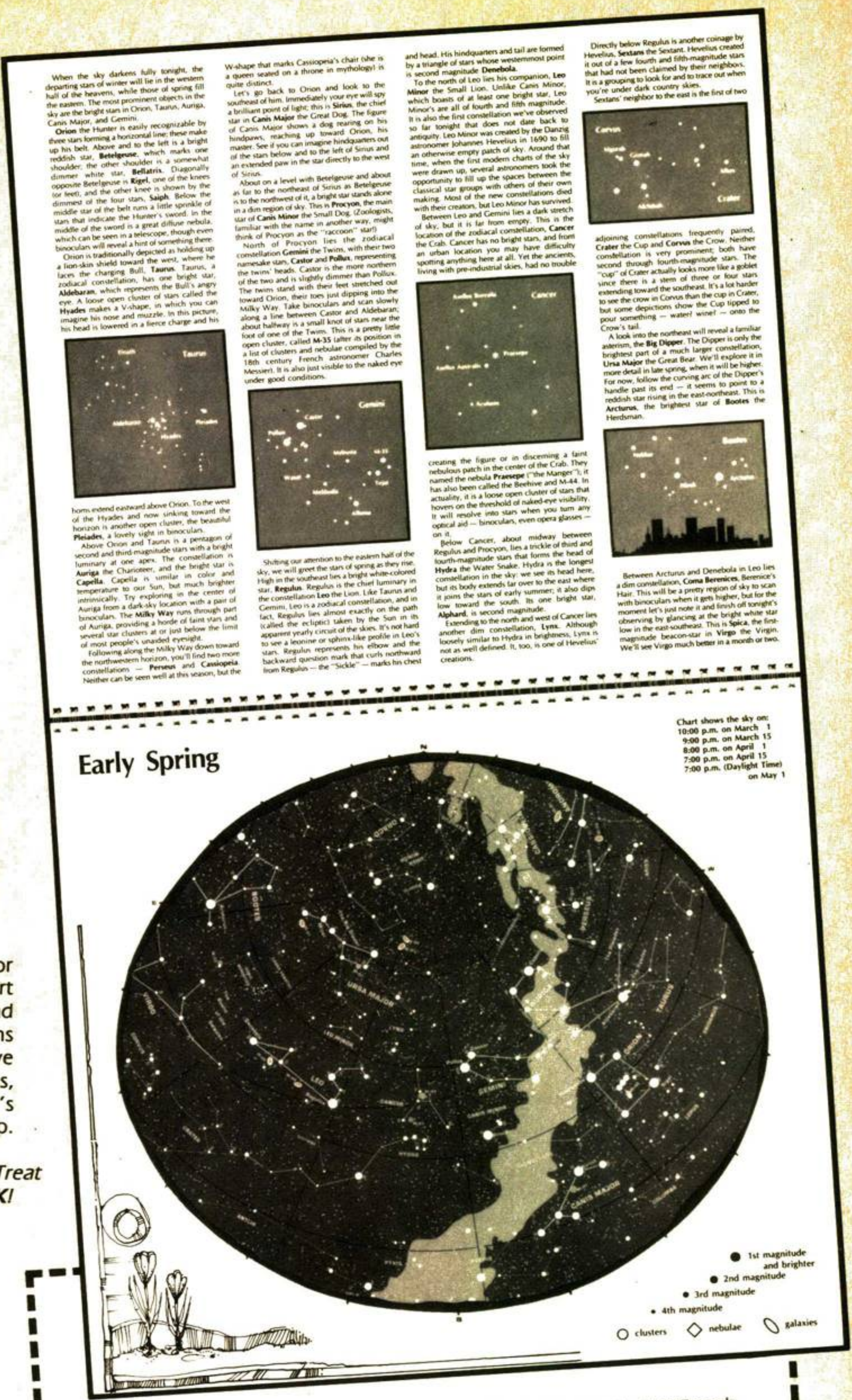

When the sky darkens fully tonight, the departing stars of winter will lie in the western half of the heavens, while those of spring fill the eastern. The most prominent objects in the sky are the bright stars in Orion, Taurus, Auriga, Canis Major, and Gemini.

Orion the Hunter is easily recognizable by three stars forming a horizontal line; these make up his belt. Above and to the left is a bright reddish star, **Betelgeuse**, which marks one shoulder; the other shoulder is a somewhat dimmer white star, **Bellatrix**. Diagonally opposite Betelgeuse is **Rigel**, one of the knees (or feet), and the other knee is shown by the dimmest of the four stars, **Saiph**. Below the middle star of the belt runs a little sprinkle of stars that indicate the Hunter's sword. In the middle of the sword is a great diffuse nebula, which can be seen in a telescope, though even binoculars will reveal a hint of something there.

Orion is traditionally depicted as holding up a lion-skin shield toward the west, where he faces the charging Bull, **Taurus**. Taurus, a zodiacal constellation, has one bright star, **Aldebaran**, which represents the Bull's angry eye. A loose open cluster of stars called the **Hyades** makes a V-shape, in which you can imagine his nose and muzzle. In this picture, his head is lowered in a fierce charge and his horns extend eastward above Orion. To the west of the Hyades and now sinking toward the horizon is another open cluster, the beautiful **Pleiades**, a lovely sight in binoculars.

Above Orion and Taurus is a pentagon of second and third-magnitude stars with a bright luminary at one apex. The constellation is **Auriga** the Charioteer, and the bright star is **Capella**. Capella is similar in color and temperature to our Sun, but much brighter intrinsically. Try exploring in the center of Auriga from a dark-sky location with a pair of binoculars. The **Milky Way** runs through part of Auriga, providing a horde of faint stars and several star clusters at or just below the limit of most people's unaided eyesight.

Following along the Milky Way down toward the northwestern horizon, you'll find two more constellations — **Perseus** and **Cassiopeia**. Neither can be seen well at this season, but the W-shape that marks Cassiopeia's chair (she is a queen seated on a throne in mythology) is quite distinct.

Let's go back to Orion and look to the southeast of him. Immediately your eye will spy a brilliant point of light; this is **Sirius**, the chief star in **Canis Major** the Great Dog. The figure of Canis Major shows a dog rearing on his hindpaws, reaching up toward Orion, his master. See if you can imagine hindquarters out of the stars below and to the left of Sirius and an extended paw in the star directly to the west of Sirius.

About on a level with Betelgeuse and about as far to the northeast of Sirius as Betelgeuse is to the northwest of it, a bright star stands alone in a dim region of sky. This is **Procyon**, the main star of **Canis Minor** the Small Dog. (Zoologists, familiar with the name in another way, might think of Procyon as the "raccoon" star!)

North of Procyon lies the zodiacal constellation **Gemini** the Twins, with their two namesake stars, **Castor** and **Pollux**, representing the twins' heads. Castor is the more northern of the two and is slightly dimmer than Pollux. The twins stand with their feet stretched out toward Orion, their toes just dipping into the Milky Way. Take binoculars and scan slowly along a line between Castor and Aldebaran; about halfway is a small knot of stars near the foot of one of the Twins. This is a pretty little open cluster, called **M-35** (after its position in a list of clusters and nebulae compiled by the 18th century French astronomer Charles Messier). It is also just visible to the naked eye under good conditions.

Shifting our attention to the eastern half of the sky, we will greet the stars of spring as they rise. High in the southeast lies a bright white-colored star, **Regulus**. Regulus is the chief luminary in the constellation **Leo** the Lion. Like Taurus and Gemini, Leo is a zodiacal constellation, and in fact, Regulus lies almost exactly on the path (called the ecliptic) taken by the Sun in its apparent yearly circuit of the skies. It's not hard to see a leonine or sphinx-like profile in Leo's stars. Regulus represents his elbow and the backward question mark that curls northward from Regulus — the "Sickle" — marks his chest and head. His hindquarters and tail are formed by a triangle of stars whose westernmost point is second magnitude **Denebola**.

To the north of Leo lies his companion, **Leo Minor** the Small Lion. Unlike Canis Minor, which boasts of at least one bright star, Leo Minor's are all of fourth and fifth magnitude. It is also the first constellation we've observed so far tonight that does not date back to antiquity. Leo Minor was created by the Danzig astronomer Johannes Hevelius in 1690 to fill an otherwise empty patch of sky. Around that time, when the first modern charts of the sky were drawn up, several astronomers took the opportunity to fill up the spaces between the classical star groups with others of their own making. Most of the new constellations died with their creators, but Leo Minor has survived.

Between Leo and Gemini lies a dark stretch of sky, but it is far from empty. This is the location of the zodiacal constellation, **Cancer** the Crab. Cancer has no bright stars, and from an urban location you may have difficulty spotting anything here at all. Yet the ancients, living with pre-industrial skies, had no trouble creating the figure or in discerning a faint nebulous patch in the center of the Crab. They named the nebula **Praesepe** ("the Manger"); it has also been called the Beehive and M-44. In actuality, it is a loose open cluster of stars that hovers on the threshold of naked-eye visibility. It will resolve into stars when you turn any optical aid — binoculars, even opera glasses — on it.

Below Cancer, about midway between Regulus and Procyon, lies a trickle of third and fourth-magnitude stars that forms the head of **Hydra** the Water Snake. Hydra is the longest constellation in the sky: we see its head here, but its body extends far over to the east where it joins the stars of early summer; it also dips low toward the south. Its one bright star, **Alphard**, is second magnitude.

Extending to the north and west of Cancer lies another dim constellation, **Lynx**. Although loosely similar to Hydra in brightness, Lynx is not as well defined. It, too, is one of Hevelius' creations.

Directly below Regulus is another coinage by Hevelius, **Sextans** the Sextant. Hevelius created it out of a few fourth and fifth-magnitude stars that had not been claimed by their neighbors. It is a grouping to look for and to trace out when you're under dark country skies.

Sextans' neighbor to the east is the first of two adjoining constellations frequently paired, **Crater** the Cup and **Corvus** the Crow. Neither constellation is very prominent; both have second through fourth-magnitude stars. The "cup" of Crater actually looks more like a goblet since there is a stem of three or four stars extending toward the southeast. It's a lot harder to see the crow in Corvus than the cup in Crater, but some depictions show the Cup tipped to pour something — water? wine? — onto the Crow's tail.

A look into the northeast will reveal a familiar asterism, the **Big Dipper**. The Dipper is only the brightest part of a much larger constellation, **Ursa Major** the Great Bear. We'll explore it in more detail in late spring, when it will be higher. For now, follow the curving arc of the Dipper's handle past its end — it seems to point to a reddish star rising in the east-northeast. This is **Arcturus**, the brightest star of **Bootes** the Herdsman.

Between Arcturus and Denebola in Leo lies a dim constellation, **Coma Berenices**, Berenice's Hair. This will be a pretty region of sky to scan with binoculars when it gets higher, but for the moment let's just note it and finish off tonight's observing by glancing at the bright white star low in the east-southeast. This is **Spica**, the first-magnitude beacon-star in **Virgo** the Virgin. We'll see Virgo much better in a month or two.

Early Spring

Chart shows the sky on:
10:00 p.m. on March 1
9:00 p.m. on March 15
8:00 p.m. on April 1
7:00 p.m. on April 15
7:00 p.m. (Daylight Time) on May 1

● 1st magnitude and brighter
● 2nd magnitude
● 3rd magnitude
● 4th magnitude
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How to Plot Star Maps On Your Computer

Your computer can become a tiny desktop planetarium.

Ever since the computer age began, amateur astronomers have dreamed of plotting star maps on a computer screen. Until recently, however, satisfactory maps weren't possible except with high-priced, high-resolution graphics systems. But relatively cheap technology has made it at last: with the advent of the Macintosh, the DEC Rainbow, and various add-on boards for the IBM-PC, computer star maps have finally come home.

Older computers set up primarily for text and numbers usually don't have the built-in hardware to run good-looking graphics. They're great for making letters and numbers and some can do graphics using a special character set. Instead of printing a letter or number on the screen, they print a block pattern. The screen may be 160 blocks wide by something like 72 blocks high. Plotting star maps is then simply a matter of turning the right blocks on — but the programming is arcane and the resulting plot looks crude.

Many of today's newer computers use a bit-mapped screen. They display letters and numbers by switching on arrays of little image dots called pixels. There may be 500 or more pixels across the screen — a big jump over block graphics. The older computers had this many pixels, too, but couldn't control single pixels. The hardware wasn't designed for it. Newer computers have hardware that allows them to switch individual pixels on and off under software control. It's an interesting paradox that the new machines may print text slower than the older machines because their incredibly high-powered microprocessors spend their time making letters and numbers from pixels. They may be slow for text — but their graphics are beautiful.

Okay — the hardware and software now exist. How can we use it?

The Database

A star map consists of dots printed on paper, or, in this case, pixels on a computer screen. The process of making the map is nothing more than turning the right pixels on. What you need is information — the intelligence that tells you which pixels should glow. Few aspects of digital computers are more intriguing than their ability to transform information from one form to another. And one of computing's most exciting possibilities is transforming a dry-as-dust list of stellar data into a sparkling imitation of the night sky. As you will soon see, the process is surprisingly easy to program and the results are stunning.

But before we get into the nitty-gritty of data files and programs, we must digress. What is it we're starting with, and what do we want the computer to do with it?

"Simple," you say. "We'll get a book that has a list of all the stars we want to plot. Then we'll plot them."

That's the starting point: a table of numbers known as a database. If you do things our way, the database consists of 1573 text strings each 28 characters long plus a carriage return. A string represents information about a single star. Although we will offer you an easy way out, there is no better way to appreciate information than inputting it yourself. The database consists of roughly 45,600 keystrokes; at the entirely reasonable pace of one page (50 stars) per night, keying it in shouldn't take you more than 30 minutes per night every night for a month.

The database comes from the table of bright stars printed in the U.S. Naval Observatory's *Astronomical Almanac* beginning on page H2. The list is over 30 pages long; it's a good list because it includes, more or less, all of the easily-visible stars in the sky. It's also a list rich in tradition — an expanded version of Claudius Ptolemeus' great star catalog the *Almagest*, itself a compilation of star catalogs dating four or five centuries earlier.

Why do we suggest you key the star

database into the computer? Simply this: compared to the effort of obtaining the data in the first place, transcribing the digits representing this information is trivial. Imagine yourself as Ptolemy, Hevelius, Flamsteed, and Argelander all rolled into one, measuring the places of each of the stars in the sky. Imagine the long cold nights, the primitive equipment, the ink frozen in your quill pen, the thrill of computing with logarithms. The list you're typing represents the lifework of many great astronomers. You should do something to *earn* that information. Besides, when you key it in yourself, you'll get close to the data. Its stars will become your friends. A week into the list, you'll meet Betelgeuse; Regulus greets you at the end of the second week; Antares at the beginning of the fourth. When you look up at the dome of stars overhead, your mind will overlay their glitter with glowing-green columns of numbers: data, information, truth.

You'll come to appreciate the quick motions of your fingers, how your eyes transform the information represented by the black marks on paper into numbers in your mind, how your fingers nimbly tap the keys to transform the information into bit patterns in computer memory and then into magnetic domains on a floppy disk.

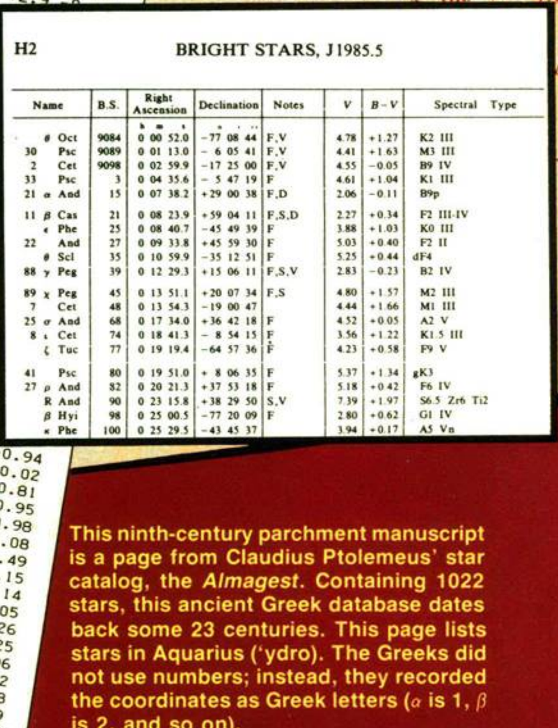
You'll gain a gut feel for the nature of information. You'll find that a digit out of place means that it means something else. A "1" followed by "2" is not a "2" followed by "1." The right number in column 21 is the wrong number in column 22. A missing blank space alters the meaning of the whole line. As the stars march by, they'll become rows of numbers, then keystrokes, then tiny abstract symbols with no meaning at all — except the meaning you invest in them.

Or you can be Phillistine and order a diskette with the datafile already on it from AstroMedia, or download it — all 48K — from your local CompuServe node. Quick, clean, effortless, and thoroughly modern. Yes, that's another lesson: Once you have information, it's easy to copy it and move it around.

We'll set up each item of data in the following string format: GGGCCC HHMMD+DDMM +M.M +C.CC. The first three characters, GGG, represent the Greek letter name of the star *or* the first two characters of the Greek letter plus a superscript number *or* the Flamsteed number. CCC represents the standard three-letter abbreviation of the constellation name. If the star has neither a Greek letter nor Flamsteed number designation, replace the entire string GGGCCC by HRnnnn, where nnnn is the four-digit *Yale Bright Star Catalogue* number given in the *Astronomical Almanac.*

HHMMD+DDMM represents the star's location in right ascension and declination coordinates for epoch 2000.0: HH is hours, MM is minutes, D is decimal minutes of RA, +DD is the declination

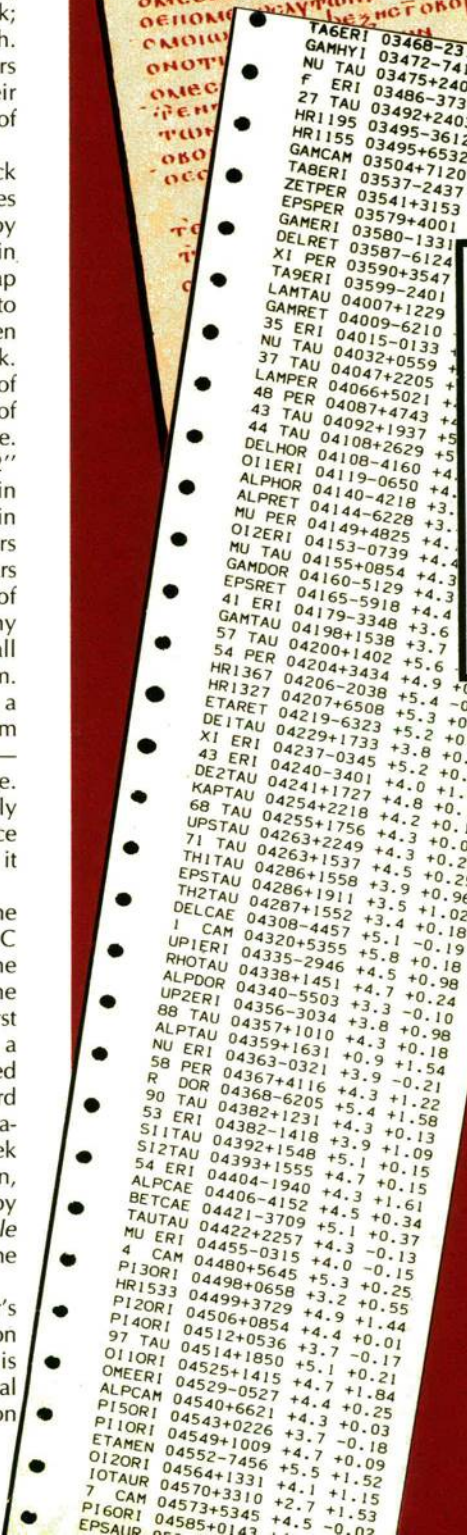
This ninth-century parchment manuscript is a page from Claudius Ptolemeus' star catalog, the *Almagest*. Containing 1022 stars, this ancient Greek database dates back some 23 centuries. This page lists stars in Aquarius ('ydro). The Greeks did not use numbers; instead, they recorded the coordinates as Greek letters (α is 1, β is 2, and so on).



H2 BRIGHT STARS, J1985.5

Name	B.S.	Right Ascension	Declination	Notes	V	B − V	Spectral Type
		h m s	° ′ ″				
θ Oct	9084	0 00 52.0	−77 08 44	F,V	4.78	+1.27	K2 III
30 Psc	9089	0 01 13.0	− 6 05 41	F,V	4.41	+1.63	M3 III
2 Cet	9098	0 02 59.9	−17 25 00	F,V	4.55	−0.05	B9 IV
33 Psc	3	0 04 35.6	− 5 47 19	F	4.61	+1.04	K1 III
21 α And	15	0 07 38.2	+29 00 38	F,D	2.06	−0.11	B9p
11 β Cas	21	0 08 23.9	+59 04 11	F,S,D	2.27	+0.34	F2 III-IV
ε Phe	25	0 08 40.7	−45 49 39	F	3.88	+1.03	K0 III
22 And	27	0 09 33.8	+45 59 30	F	5.03	+0.40	F2 II
θ Scl	35	0 10 59.9	−35 12 51	F	5.25	+0.44	dF4
88 γ Peg	39	0 12 29.3	+15 06 11	F,S,V	2.83	−0.23	B2 IV
89 χ Peg	45	0 13 51.1	+20 07 34	F,S	4.80	+1.57	M2 III
7 Cet	48	0 13 54.3	−19 00 47		4.44	+1.66	M1 III
25 σ And	68	0 17 34.0	+36 42 18	F	4.52	+0.05	A2 V
8 ι Cet	74	0 18 41.3	− 8 54 15	F	3.56	+1.22	K1.5 III
ζ Tuc	77	0 19 19.4	−64 57 36	F	4.23	+0.58	F9 V
41 Psc	80	0 19 51.0	+ 8 06 35	F	5.37	+1.34	gK3
27 ρ And	82	0 20 21.3	+37 53 18	F	5.18	+0.42	F6 IV
R And	90	0 23 15.8	+38 29 50	S,V	7.39	+1.97	S6.5 Zr6 Ti2
β Hyi	98	0 25 00.5	−77 20 09	F	2.80	+0.62	G1 IV
κ Phe	100	0 25 29.5	−43 45 37		3.94	+0.17	A5 Vn

A modern stellar database from the *Astronomical Almanac* gives the star name and constellation, *Bright Star Catalogue* number, right ascension and declination for epoch 1985, notes, visual magnitude, the B-V color index, and spectral type for every star brighter than magnitude 4.5, plus selected fainter stars.



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TA6ERI 03468-2315 +4.2 +0.42
GAMHYI 03472-7414 +3.2 +1.62
NU TAU 03475+2406 +2.9 -0.09
f  ERI 03486-3737 +4.2 -0.01
27 TAU 03492+2403 +3.6 -0.08
HR1195 03495-3612 +4.2 +0.95
HR1155 03495+6532 +4.5 +1.88
GAMCAM 03504+7120 +4.6 +0.03
TABERI 03537-2437 +4.5 +0.09
ZETPER 03541+3153 +2.9 +0.12
EPSPER 03579+4001
GAMERI 03580-1331
DELRET 03587-6124
XI PER 03590+3547
TA9ERI 03599-2401
LAMTAU 04007+1229
GAMRET 04009-6210
35 ERI 04015-0133
NU TAU 04032+0559 +
37 TAU 04047+2205 +
LAMPER 04066+5021 +
48 PER 04087+4743 +4
43 TAU 04092+1937 +5
44 TAU 04108+2629 +5
DELHOR 04108-4160 +4.
OI1ERI 04119-0650 +4.
ALPHOR 04140-4218 +3.
ALPRET 04144-6228 +3.
MU PER 04149+4825 +4.
OI2ERI 04153-0739 +4.4
MU TAU 04155+0854 +4.3
GAMDOR 04160-5129 +4.3
EPSRET 04165-5918 +4.4
41 ERI 04179-3348 +3.6
GAMTAU 04198+1538 +3.7
57 TAU 04200+1402 +5.6
54 PER 04204+3434 +4.9 +0.94
HR1367 04206-2038 +5.4 -0.02
HR1327 04207+6508 +5.3 +0.81
ETARET 04219-6323 +5.2 +0.95
DE1TAU 04229+1733 +3.8 +0.98
XI ERI 04237-0345 +5.2 +0.08
43 ERI 04240-3401 +4.0 +1.49
DE2TAU 04241+1727 +4.8 +0.15
KAPTAU 04254+2218 +4.2 +0.14
68 TAU 04255+1756 +4.3 +0.05
UPSTAU 04263+2249 +4.3 +0.26
71 TAU 04263+1537 +4.5 +0.25
THITAU 04286+1558 +3.9 +0.96
EPSTAU 04286+1911 +3.5 +1.02
TH2TAU 04287+1552 +3.4 +0.18
DELCAE 04308-4457 +5.1 -0.19
1  CAM 04320+5355 +5.8 +0.18
UP1ERI 04335-2946 +4.5 +0.98
RHOTAU 04338+1451 +4.7 +0.24
ALPDOR 04340-5503 +3.3 -0.10
UP2ERI 04356-3034 +3.8 +0.98
88 TAU 04357+1010 +4.3 +0.18
ALPTAU 04359+1631 +0.9 +1.54
NU ERI 04363-0321 +3.9 -0.21
58 PER 04367+4116 +4.3 +1.22
R  DOR 04368-6205 +5.4 +1.58
90 TAU 04382+1231 +4.3 +0.13
53 ERI 04382-1418 +3.9 +1.09
SI1TAU 04392+1548 +5.1 +0.15
SI2TAU 04393+1555 +4.7 +0.15
54 ERI 04404-1940 +4.3 +1.61
ALPCAE 04406-4152 +4.5 +0.34
BETCAE 04421-3709 +5.1 +0.37
TAUTAU 04422+2257 +4.3 -0.13
MU ERI 04455-0315 +4.0 -0.15
4  CAM 04480+5645 +5.3 +0.25
PI3ORI 04498+0658 +3.2 +0.55
HR1533 04499+3729 +4.9 +1.44
PI2ORI 04506+0854 +4.4 +0.01
PI4ORI 04512+0536 +3.7 -0.17
97 TAU 04514+1850 +5.1 +0.21
OI1ORI 04525+1415 +4.7 +1.84
OMEERI 04529-0527 +4.4 +0.25
ALPCAM 04540+6621 +4.3 +0.03
PI5ORI 04543+0226 +3.7 -0.18
PI1ORI 04549+1009 +4.7 +0.09
ETAMEN 04552-7456 +5.5 +1.52
OI2ORI 04564+1331 +4.1 +1.15
IOTAUR 04570+3310 +2.7 +1.53
7  CAM 04573+5345 +4.5 -0.02
PI6ORI 04585+0143
EPSAUR
```

Part of our computer database. A list such as this can be entered into the computer using a text editor or word processor, downloaded from CompuServe, or purchased on a diskette from AstroMedia. The name column here is rather cryptic, a by-product of a complex history of star-naming conventions.

degrees, and MM is declination minutes. As given, these coordinates are sufficiently precise for fields as small as 10 degrees across.

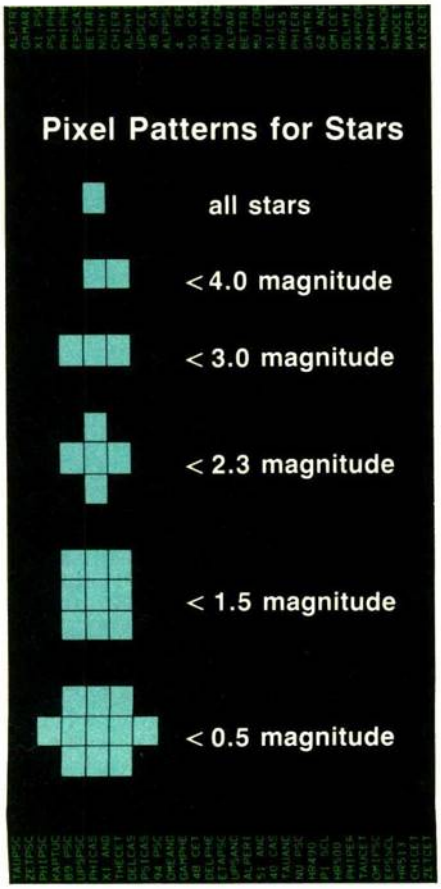
The +M.M is the star's magnitude in yellow light — a measure of its brightness to the eye. The plus or minus sign is necessary because some of the brightest stars, like Sirius, have negative magnitudes. The dimmest objects on the list are variable stars dimmer than sixth magnitude.

Finally, +C.CC is the color index of the star. This number ranges from −0.25 to +2.5. The bluest stars have color indices less than zero, while stars we usually call red have color indices of 1.8 or greater. The Sun has a color index of +0.62, and it is a yellow-white star. Although the program does not use the color data, if you've got a computer with a color monitor you may want to plot the stars in color.

That about does it for the database. You can type it in with a word processor, download it from CompuServe, or order a diskette from AstroMedia. Quite frankly, we recommend the first method. That's how we did it. Besides, it'll be good for you.

The Program

STARS.BAS converts the database into a screen display. This version works with IBM's standard 640x200 pixel screen and compatible models (it's been tested on a Zenith 150) or with the 720x348 pixel screen of the Hercules Graphics Card. Take your pick. It is easy to adapt the program to powerful graphics machines like the Macintosh. Before running the program, edit lines 40 and 50 to activate the correct machine parameters.


Pixel Patterns for Stars

STARS begins by asking for the RA and DEC coordinates of the center of your field of view. (If you don't understand equatorial coordinates, you'll soon be lost.) For starters, enter 5.5 hours and 0 degrees to see the bright constellation Orion, or 12 hours and +55 degrees for the Big Dipper.

Next you input the width of the field of view. Angles between 60 and 120 generally produce the most attractive maps. Fields of 30 degrees typically include only one constellation; field angles greater than 240 degrees show too many stars and the display looks crowded. It's your choice whether you want border lines and beeps. The beeps seem to make time pass a little faster while the machine is plotting a map, though.

After you've typed the parameters for the first map, the program loads the database into the computer's memory. This takes about 10 minutes, so go for a break. After it's loaded the data, the program hops to a point in the array where it can begin plotting stars, then proceeds forward through the database. When it begins to run shy of stars to plot, the program hops back to the starting point and works through the database backward from here. It may hop back and forth several times before filling the screen completely.

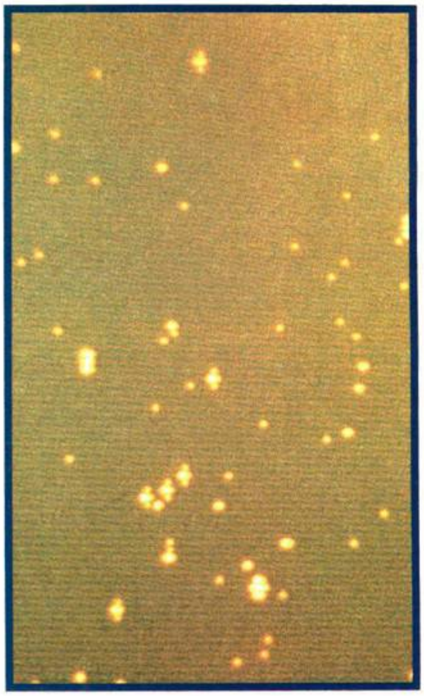
You can cancel a plot in progress by typing X, and then start a new map by typing N. Typing Q ends the program. When it plots the second map, STARS.BAS does not reload the array but plots from the data which is already in memory.

Lines 10 through 100 establish the type of machine, assign the size of the screen in pixels to SX and SY, dimension the arrays, and set the values of pi and degrees per radian. If you're adapting STARS.BAS to the Macintosh, for example, replace line 60 with:

```
60 SX=512:SY=348:YHT=1.
```

This will take care of graphics constants throughout the rest of the program.

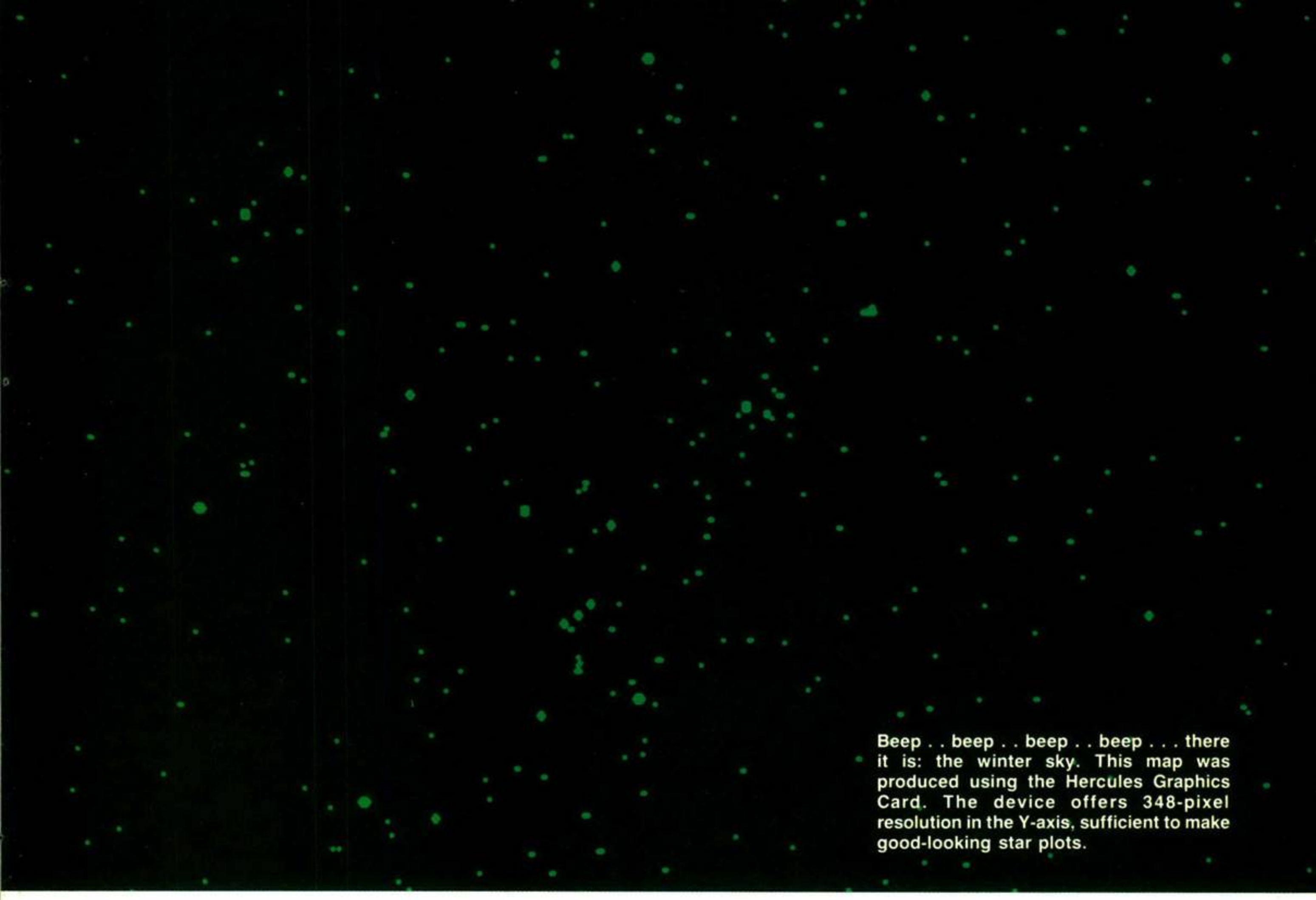
Lines 110 through 270 take the starfield parameters, RA0, DEC0, and WID from the keyboard, and also set the Boolean variables LIN and BP which control the border line and whether the computer will beep when it plots a star. Line 240 finds the internal variables for the field center in radians and a scale factor, R, based on WID. At line 250 on the first time through the program, the Boolean ARLD (for array load) is false so the program skips to the array loading subroutine starting at line 660.


This closeup shows about one-fourth of a 640x200-pixel graphics-mode screen — the IBM standard. Although the pixel structure is rather coarse, from a distance the star blobs look reasonably natural. Screens with lower resolution produce even coarser stars.

Line 660 simply reassures the user that the computer is doing something. The next line opens the datafile and line 690 reads a line of data. Line 700 checks that the line doesn't begin with an "*." We used an "*" to put little messages in the file when it was being compiled; this line no longer does anything. Line 710 reads the eighth and ninth characters from the data line and converts them from a string to a numerical value; it then adds to this the values of the three characters following the tenth character divided by 600. The result is the RA in decimal hours. In line 750, this is multiplied by 0.2618 to convert it to radian measure.

Lines 720, 730, and part of 740 convert the five characters representing the declination into its numeric value in decimal hours, and line 750 converts the value in degrees to radians. The rest of line 740 gets the star's magnitude. In line 750, we place the values for RA, DEC, and MAG into corresponding arrays. The next line raises the array counter by one and, if you're not using a Hercules Graphics Card (HGC is another Boolean variable), prints the data string. The Hercules Card is rather slow, so it's best not to use it while loading the arrays. When we reach the end of the file, line 680 assigns the number of stars to NUM%, sets ARLD to −1 which means "true," beeps twice, and returns from the subroutine.

Line 260 clears the screen, turns on graphics mode, and blanks those nasty little function-key bugs at the bottom of IBM's BASIC screen. In the Macintosh, you should paint the screen black here. If you want a border around the map, line 270 draws it for you. Everything's now



Beep . . beep . . beep . . beep . . . there it is: the winter sky. This map was produced using the Hercules Graphics Card. The device offers 348-pixel resolution in the Y-axis, sufficient to make good-looking star plots.

loaded and ready to go.

Lines 290 and 300 figure out where to start plotting stars. We take a guess at the array index, J%, by going the same distance into the array as our central RA is around the sky. Got that? We set the step, STP%, to +1 and take a guess at the number of stars we're willing to miss before doing something about it (that's MSN%). We also assign the current value of J% to both LOL%, the lower limit, and also to UPL%, the upper limit, since we haven't plotted anything yet. Note that we've defined the variables as integers by the % character. Most computers handle integers faster than real numbers.

We get down to the nitty gritty in line 320, assigning the J%th array values to new variables. DLAM is the difference between the star's RA and the RA of the center of the field. It next computes — in lines 330, 340, and 350 — the sines and cosines we need. This allows the machine to calculate each of these transcendental functions only once and noticeably speeds up the program. Lines 360 and 370 do the coordinate transform. Line 380 returns X and Y in screen coordinates.

We then check whether the star is on the screen or not. If it's off screen in the X-axis, we add one to the number missing and go to line 500 to update the array value before getting another star. If it's off-screen in the Y-axis, we go to line 500 without increasing the number missed.

Lines 410 through 470 plot the star. We've used the PSET function to build up a star image consisting of between one and 11 pixels, depending on the brightness of the star. It's entirely possible to use the CIRCLE and PAINT functions to make the star, but maps made this way tend to look less realistic. If you'd like to experiment, we suggest you delete lines 410 through 470 and insert a new line

```
485 Z=(5-MAG)/2 :
    CIRCLE (X,Y),Z,YHT:
    PAINT (X,Y).
```

Lines 510 through 580 clean up after the star. If we're counting down the array, line 510 assigns the new upper or lower limit. Line 520 acts if we've missed plotting too many stars, line 520 switches the sign of the step and doubles the number of acceptable misses. Line 530 assigns a new value to J% by adding the step size to the previous upper or lower limit.

Lines 540 and 550 make sure we don't run off the bottom end or top of the array. Line 560 checks the keyboard buffer to see if we've tried to cancel the plot by typing an upper case X. Line 570 checks that we haven't plotted more stars than there are in the array; if we haven't, it returns us to line 320 for another star.

This scheme sounds pretty complicated,

Computer owners with a modem can download STARS.BAS and STARS.DAT from CompuServe's Public Access Area. CompuServe is a major on-line computing company. It costs about $40 to join (starter packages are sold at many computer stores) and $6 per hour for evening connect time. From the Access Area (PCS-46), type:

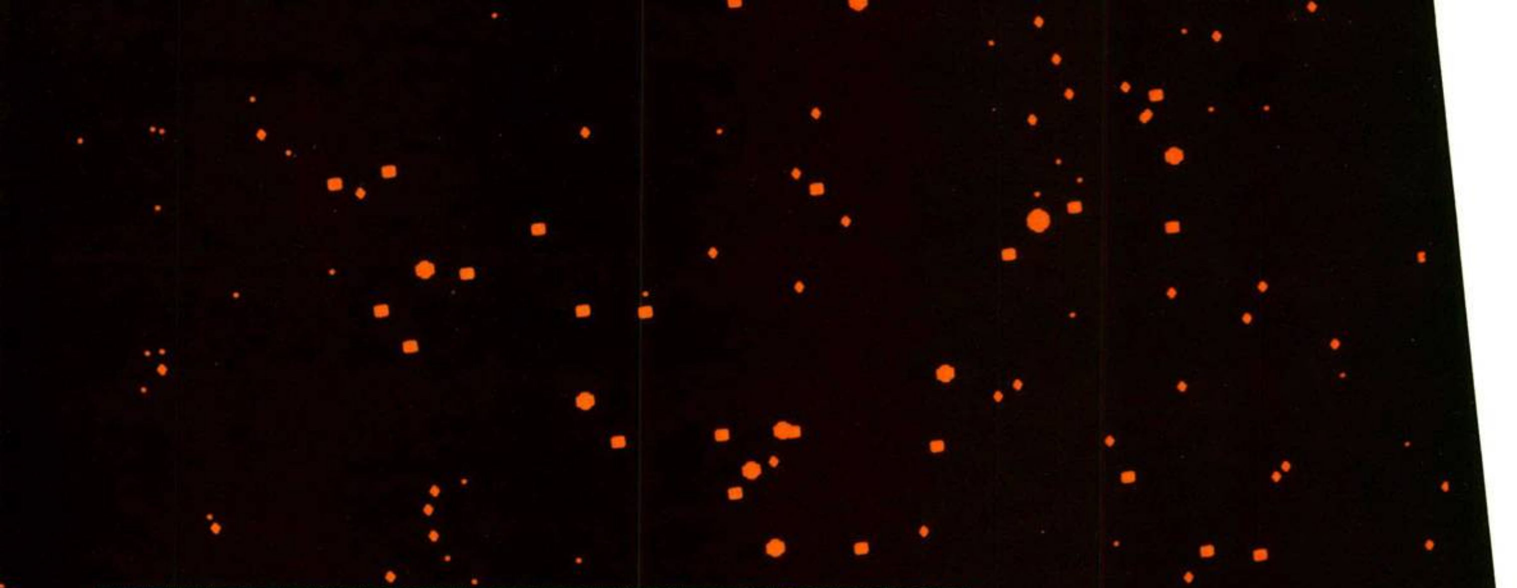
R STARS.DOC[74206,110]

at any prompt for program documentation along with instructions for downloading the program and database. You will also need the program, which is listed as STARS.BAS [74206,110].

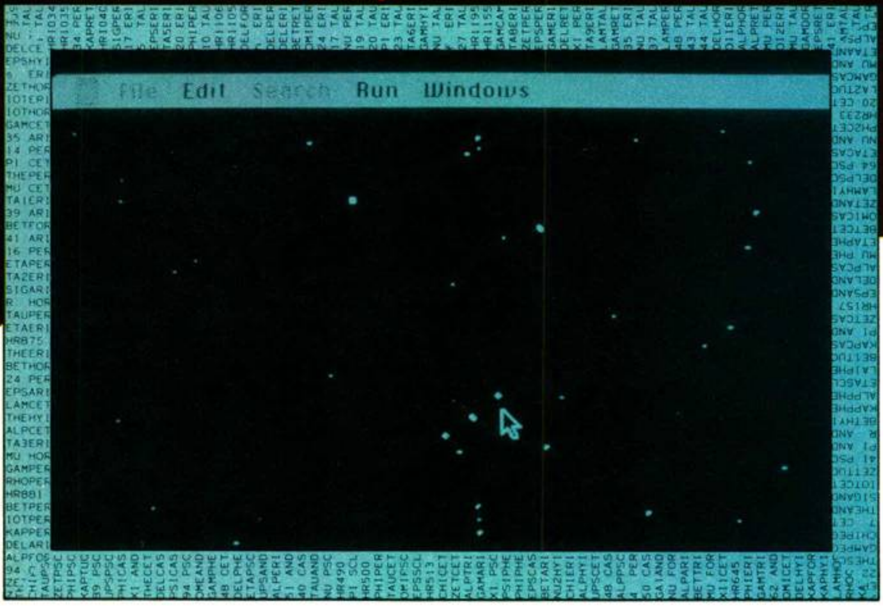
In order to help the owners of computers with small capture buffers, the database is divided into four files:

STARS1.DAT[74206,110]
STARS2.DAT[74206,110]
STARS3.DAT[74206,110]
STARS4.DAT[74206,110]

Each file contains one-fourth of the database, or 12,000 characters. At 300 baud, it takes about 40 minutes of connect time to download all four. Programs and documentation sometimes get "trashed" or "purged" in Access, so if you can't find these files let us know there's a problem via EasyPlex. Our user ID number is 74206,110.



Do you recognize Sagittarius and Scorpius? The biggest problem with using the CIRCLE function to make stars, as we have done here, is that you're likely to get square stars! The bigger stars may also overlap.



"That star's Mintaka," you say, maneuvering the mouse pointer from star to star, "now *you* show me Betelgeuse." With the Macintosh, you can teach kids (or adults) the constellations using a mouse. You could also save starfields for later recall, printing, or editing in MacPaint.

but it guarantees that the program plots stars right away. Although a FOR...NEXT loop seems the natural way to plot an array of stars, if the RA is fairly high the computer may sit there for 10 to 15 minutes before it reaches the first plottable star.

Finally, line 600 proudly announces that the computer is ready for new map parameters, and then the program sits and waits patiently at line 610. Keying an N starts the process all over again, except that the array need not be loaded. Q ends the program.

Of the computers we tested with STARS.BAS, Apple's Macintosh was fastest, a Zenith 150 next fastest, and an IBM-PC equipped with a Hercules Graphic Card and running HBASIC came in a sluggish third. The Macintosh plots two stars per second and loads the data array fastest. The Zenith runs about one star per second and the IBM takes about two seconds per star.

The Star Maps

After the computer has turned on an array of pixels, you'll be eyeball to eyeball with another perplexing aspect of information: interpretation and recognition. Ask a non-astronomer friend or your spouse what he or she sees on the screen. An honest reply would be "little dots" — and making little dots on the computer screen is all that you have really accomplished. These are not real stars.

But given *a priori* knowlege — in this case, knowing of your interest in astronomy — it is quite possible others will claim they see stars. Lacking your knowledge of the constellations, however, they still won't see the patterns you see. "There's Pisces," you'll say while pointing to the Circlet and tracing the ribbon of stars that join the two fish.

"Uh-huh," they'll say.

"This one's the northern fish . . . and over here, this is the southern fish," you'll continue, smudging the computer screen with your fingertip. Certainly the image on the screen, or for that matter the pattern of stars in the real sky, does little to evoke an image of fishes. Any fishiness depends on your knowlege of the constellations, and that in turn is only part of a cultural tradition not shared by all the people in our world.

Just as the color index may have been new and meaningless to you, the patterns formed by the constellations are meaningless until the light from the glowing pixels has entered your eyes and traveled to your brain to be correlated with the millions of other patterns you recognize ("Do you see yonder cloud that's almost in the shape of a camel . . . ?"), and then associated with things you've heard and read about Pisces. I can't disassociate Pisces from fishing for sunnies in Lake Winnipesaukee when I was ten years old. Such mental baggage is important when interpreting the glowing dots on the computer screen.

What good is it?

Well, it's pretty.

And it's fun.

You can use computer-generated star screens to learn the constellations or teach them to others. You can spend countless hours hacking the program until it's got all the bells and whistles you can think of — and then some.

Adding some bells and whistles suggests a programming challenge. What's the first thing non-astronomers inevitably ask?

```
10 PROG$="STARS.BAS":REM STARS.BAS[74206,110]
20 AUTH$="Written by Richard Berry, ASTRONOMY Magazine"
30 DTBS$="STARS.DAT":ARLD=0
40 MACH$="HGC":HGC=-1:REM Hercules Graphics Card
50 REM MACH$="Z-150":HGC=0:REM Z-150 w/ IBM graphics
60 SX=640:SY=200:YHT=.38:REM for IBM 640x200 graphics
70 IF HGC THEN SX=720:SY=348:YHT=.74:REM Hercules Graphics Card
80 CENTX=SX/2:CENTY=SY/2
90 DIM RA(1600),DEC(1600),MAG(1600)
100 PI=3.14159:RADIAN=PI/180
110 '---- information screen ------------------------------------
120 CLS:PRINT TAB(25) PROG$+" for the "+MACH$:PRINT
130 PRINT TAB(14) AUTH$:PRINT
140 PRINT TAB(12) PROG$+" plots a stereographic map of the sky"
150 PRINT TAB(15) "from a human-readable star database "+DTBS$
160 PRINT TAB(20) "of the region and field you select.":PRINT
170 INPUT "Enter the RA of the field center";RA0
180 INPUT "Enter the DEC of the field center";DEC0
190 INPUT "Enter the WIDTH of the field in degrees";WID
200 INPUT "Do you want a LINE surrounding the map? Y/N";LIN$
210 IF LIN$="Y" OR LIN$="y" THEN LIN=-1 ELSE LIN=0
220 INPUT "Do you want a BEEP for each star plotted? Y/N";BP$
230 IF BP$="Y" OR BP$="y" THEN BP=-1 ELSE BP=0
240 R=SX*53/WID:LAM0=.261845*RA0:PHI0=DEC0*RADIAN
250 IF NOT ARLD THEN GOSUB 660:REM load stars into arrays
260 CLS:SCREEN 2:KEY OFF
270 IF LIN THEN LINE (0,0)-(SX-1,SY-1),,B
280 '---- do setup calculations -----------------------
290 J%=INT(NUM%*LAM0/2/PI):STP%=1:MSN%=INT(NUM%/WID)
300 LOL%=J%:UPL%=J%:MSS%=0:CT%=0
310 '---- plot star on the screen ----------------------
320 PHI=DEC(J%):MAG=MAG(J%):DLAM=RA(J%)-LAM0
330 A=SIN(PHI0):B=COS(PHI0)
340 C=SIN(PHI): D=COS(PHI)
350 E=SIN(DLAM):F=COS(DLAM)
360 K0=2/(1+A*C+B*D*F)
370 X=R*K0*D*E:Y=R*K0*(B*C-A*D*F)
380 X=-X+CENTX:Y=-Y*YHT+CENTY
390 IF X>SX OR X<0 THEN MSS%=MSS%+1:GOTO 500
400 IF Y>SY OR Y<0 THEN GOTO 500
410 PSET (X,Y)
420 IF MAG<4 THEN PSET (X+1,Y)
430 IF MAG<3 THEN PSET (X-1,Y)
440 IF MAG<2.3 THEN PSET (X,Y):PSET (X,Y-1)
450 IF MAG<1.5 THEN PSET (X+1,Y+1):PSET (X-1,Y-1)
460 IF MAG<1.5 THEN PSET (X-1,Y+1):PSET (X+1,Y-1)
470 IF MAG<.5 THEN PSET (X-2,Y):PSET (X+2,Y)
480 IF MAG>5 THEN MAG=5
490 IF BP THEN SOUND (512-64*MAG),1
500 '---- reset array plot values if necessary ----------------
510 IF STP%<0 THEN LOL%=J% ELSE UPL%=J%
520 IF MSS%>MSN% THEN STP%=-STP%:MSS%=0:MSN%=2*MSN%
530 IF STP%<0 THEN J%=LOL%+STP% ELSE J%=UPL%+STP%
540 IF J%>NUM% THEN J%=0
550 IF J%<0 THEN J%=NUM%
560 K$=INKEY$:IF K$="X" THEN GOTO 600
570 CT%=CT%+1:IF CT%>NUM% THEN GOTO 600
580 GOTO 320
590 '---- when done, wait for a key. N is new, Q quits --------
600 BEEP:BEEP:BEEP:BEEP
610 K$=INKEY$:IF K$="" THEN 610
620 IF K$="N" OR K$="n" THEN GOTO 120
630 IF K$="Q" OR K$="q" THEN END
640 GOTO 610
650 '---- star array loading subroutine -----------------------
660 CLS:PRINT "Loading Star Data into Memory"
670 OPEN DTBS$ FOR INPUT AS #1:K%=0
680 IF EOF(1) THEN CLOSE:NUM%=K%-1:ARLD=-1:BEEP:BEEP:RETURN
690 INPUT#1, N$
700 IF MID$(N$,1,1)="*" THEN GOTO 680
710 RA=VAL(MID$(N$,8,2))+VAL(MID$(N$,10,3))/600
720 DSGN$=MID$(N$,13,1):IF DSGN$="-" THEN DSGN=-1 ELSE DSGN=1
730 DEC=VAL(MID$(N$,14,2))+VAL(MID$(N$,16,2))/60
740 DEC=DSGN*DEC:MAG=VAL(MID$(N$,19,4))
750 RA(K%)=RA*.2618:DEC(K%)=DEC*RADIAN:MAG(K%)=MAG
760 K%=K%+1:IF NOT HGC THEN PRINT N$
770 GOTO 680
```

As printed here, STARS.BAS should run on MicroSoft GW-BASIC or BASICA and may be modified to run on the Apple Macintosh (with pull-down menus, mice, or whatever. . .), the DEC Rainbow, and other high-resolution graphic computers with similar BASICs. As always, the user assumes responsibility for modifying and debugging the program to run on his equipment.

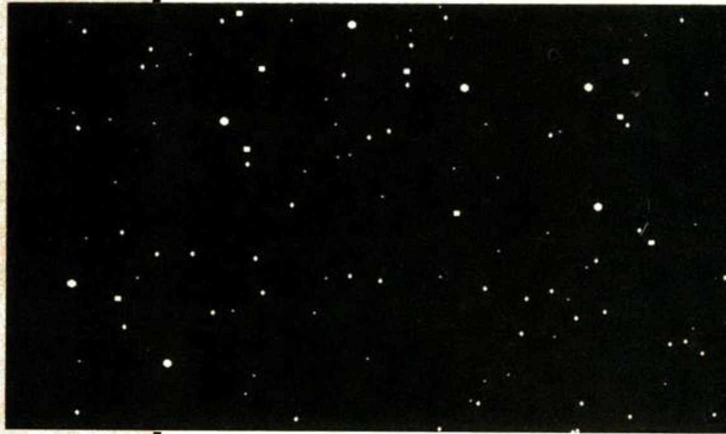
"Where are the lines?" Real astronomers know there are no lines. Problem: How can you show the lines? Got any ideas? Let us know how you solve it.

On second thought — *do* you know *all* the constellations? This is your golden opportunity to learn the southern stars before you head for your rendezvous with Halley's Comet in New Zealand.

Here's another challenge: What else can you think of to do with the database? You could try plotting all the blue stars in the sky to see how they're distributed, and then do the same for the red stars. Bright blue stars cling to the plane of the Milky Way. Can you hack up a coordinate tranform to plot stars in the galactic coordinate system? That would be interesting.

Or what about sorting the stars into order of brightness? Plot them using a FOR...NEXT loop. As they plot, it'll look like the stars coming out at night. Have fun with it. Send pictures of your best screens to ASTRONOMY. We'd like to know what you come up with.

— *Richard Berry*



This is the "mystery starfield." What constellation or constellations do you see in these dots — or have we pulled a fast one on you and plotted a random pattern of dots on the screen? One effect we've noticed is that you can't use this program without learning the constellations better . . . .

As a service to our readers, diskettes for the IBM-PC (and compatible computers) containing the files STARS.BAS and STARS.DAT are available from AstroMedia for a limited time only. The cost is $29.95. The program is not copy protected, but it contains copyrighted software. Neither the program nor the data file may be used for commercial purposes. While we cannot guarantee that the program will work properly on your computer's BASIC, if the diskette is defective we will replace it when you return the original defective diskette to us. Please use the order form bound into the magazine.

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ANNOUNCEMENT — Amateur astronomers or anyone interested in astronomy in the Huntington, West Virginia area are invited to join the Ohio Valley Astronomical Society. For more information, contact David McWhorter at (614) 886-6147 or Jerry Harris at (304) 736-5676.

ANNOUNCEMENT — The Cartin Space Foundation (associated with the World Space Foundation's Asteroid Resource Project at Palomar Observatory) seeks amateur astronomers to obtain astrometric, photometric, and radiometric observations of asteroids. Write CTSF Amateur Asteroid Network, P.O. Box 2211, New Britain, CT 06051.

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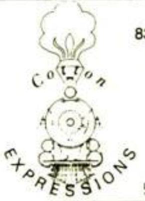

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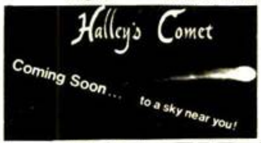
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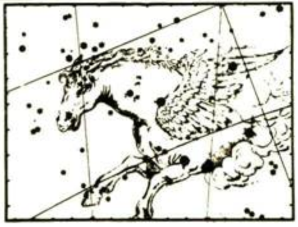

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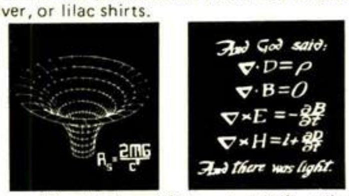
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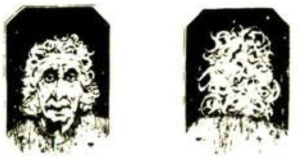
5

Front: Black hole w/ Schwartzchild's radius.
Back: Maxwell's equations of light.



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ANNOUNCEMENT — The Amateur Astronomers Association of Princeton will have an exhibit in the Community Booth at Quaker Bridge Mall, Rt. 1, Lawrenceville, New Jersey from 10 a.m. to 5 p.m. on September 14 and noon to 5 p.m. on September 15. The Association maintains an observatory in Washington Crossing State Park, New Jersey, and meets the second Tuesday of each month at 8 p.m. in Peyton Hall located on Ivy Lane of the Princeton University campus.

ANNOUNCEMENT — Attention New York and Long Island stargazers! The Amateur Observers' Society of New York meets the first Sunday of each month at the Vanderbilt Planetarium, Centerport, New York. We always have plenty of room for beginners. For details, phone Barry at (516) 541-1690 evenings.

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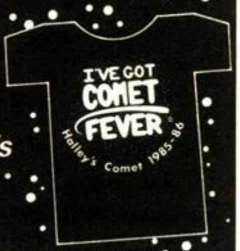

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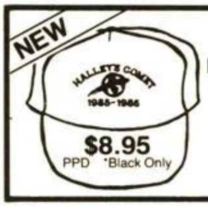

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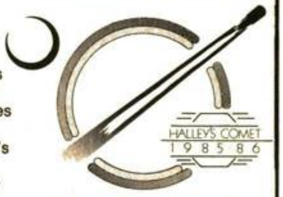

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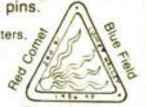

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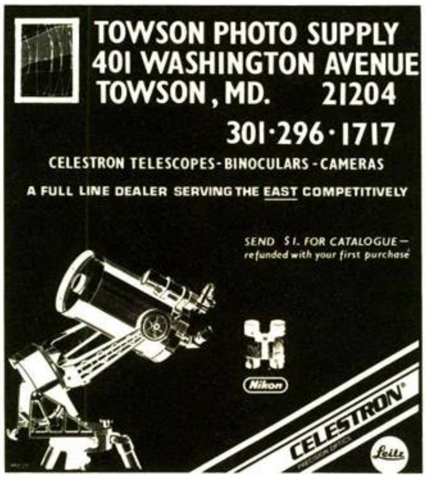

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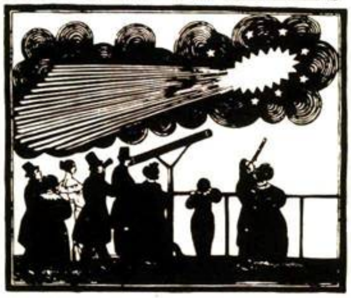

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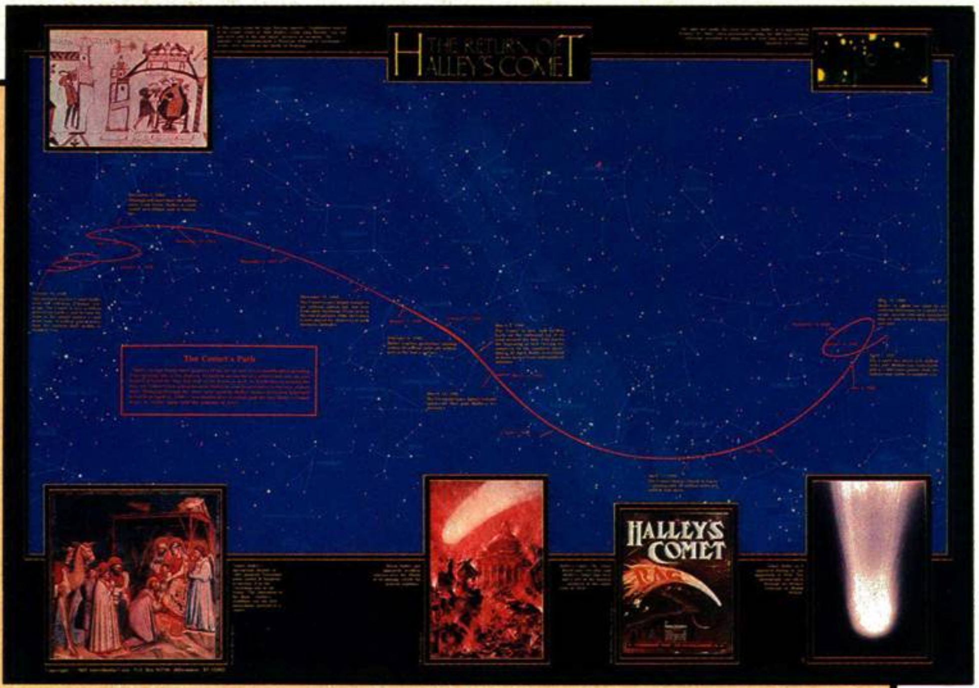

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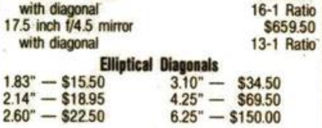

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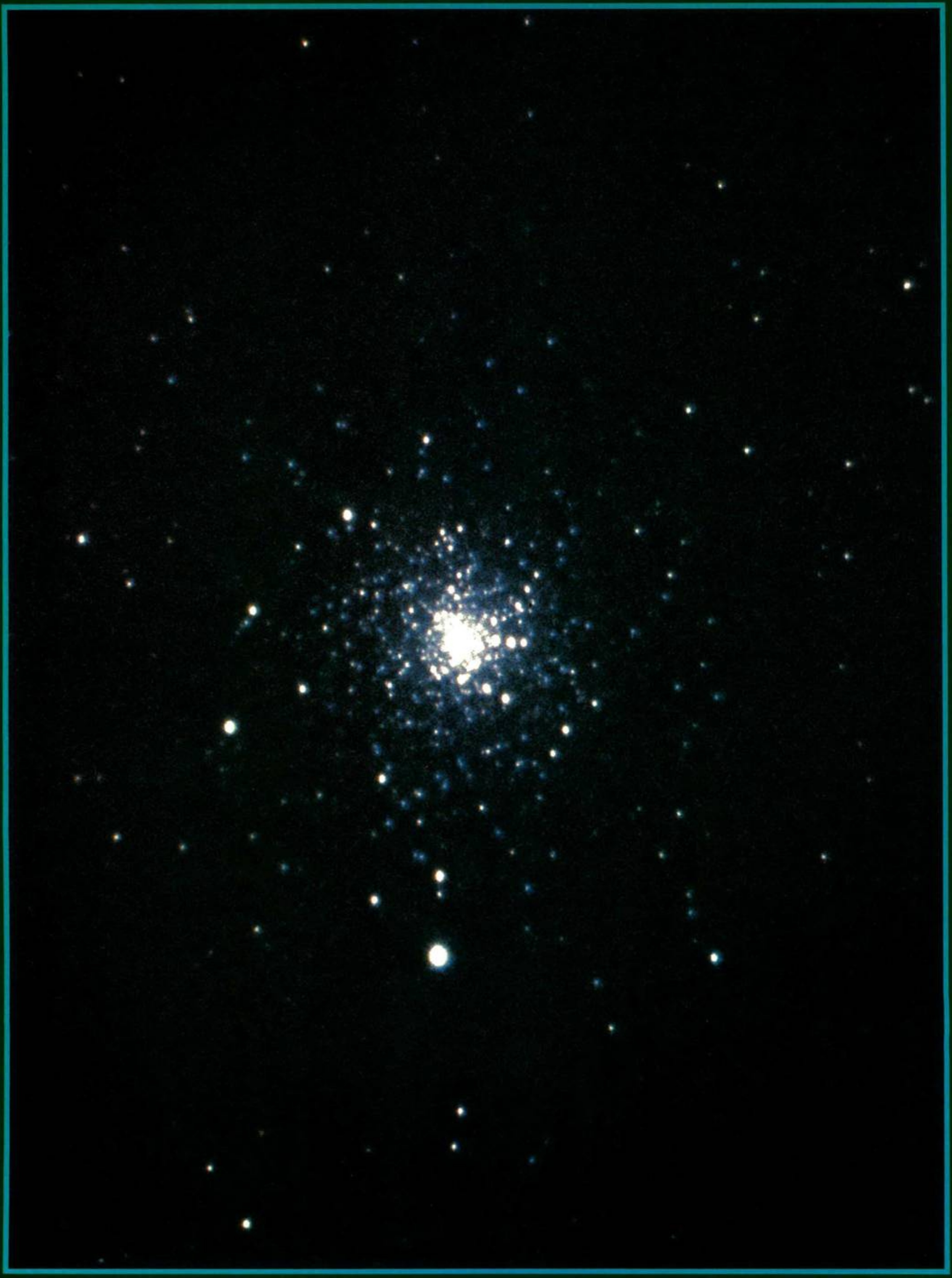
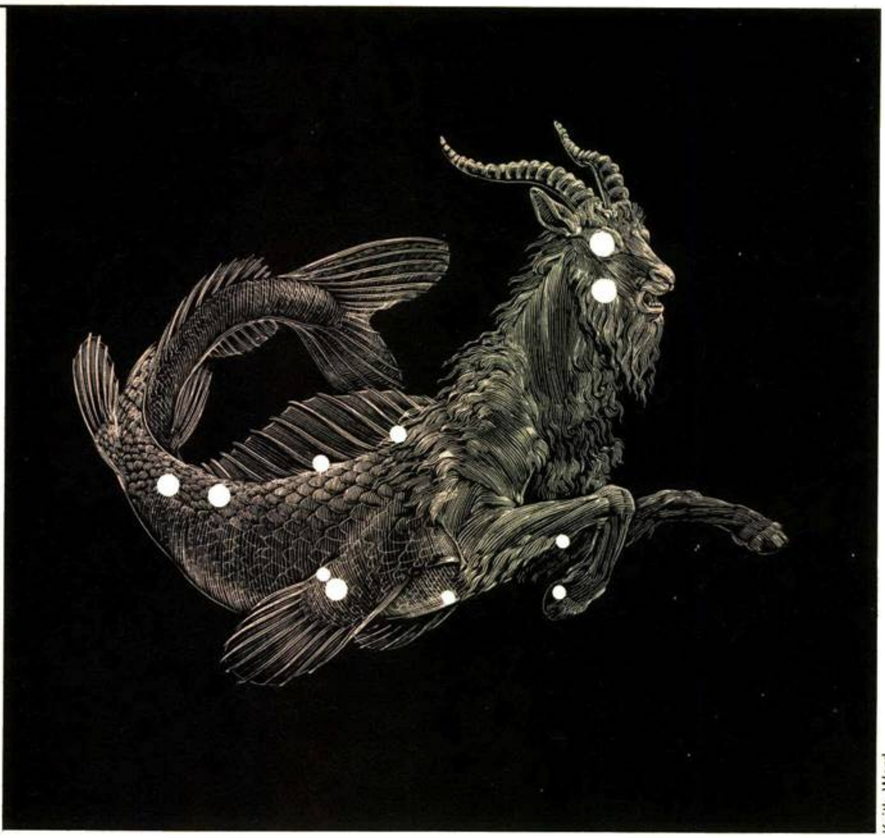


The globular cluster M-30 is bright, but small and difficult to resolve in backyard telescopes. Photo by Bill Iburg.

Capricornus

Cap
Capricorni


Keith Ward

Although it lies adjacent to the rich Milky Way in Sagittarius, the constellation **Capricornus** the Sea Goat is nearly devoid of nebulous deep-sky objects. Instead, it contains one bright globular cluster, two faint galaxies, and a great many double and variable stars.

Lying in the southeastern part of Capricornus is the fine globular star cluster **Messier 30** (NGC-7099). Measuring some 11′ across and glowing at magnitude 7.5, M-30 is one of the finest globulars in the fall sky and is easily identifiable in binoculars. It lies at a distance of 8.2 kiloparsecs, making it fairly difficult to resolve into stars. Nonetheless, a good 8 or 10-inch telescope operating under a transparent sky clearly shows M-30's edges partially resolved, while the cluster's core remains a white disk.

In the same low-power field, 25′ east and just slightly south of M-30, is the bright double star **41 Capricorni**. This double is not easy to pick out due to the great difference in magnitudes between its two components: the primary shines at magnitude 5.3, while the secondary — 5.5″ away in p.a. 205° (1954) — is a dim little star of magnitude 11.5. Try splitting this pair after you observe M-30 by centering the field of view on 41 Cap, inserting a high-power eyepiece, and — using averted vision — glancing about the field in search of the diminutive secondary.

In the opposite side of Capricornus — the northwestern part — lies the wide bright double star **Alpha^{1,2}** ($\alpha^{1,2}$) **Capricorni**. This pair of magnitude 3.6 (α^1) and 4.2 (α^2) stars, separated by over 6′, is best viewed with the naked eye or binoculars. Both stars are light yellow in color, α^2 being a spectral type G9 giant and α^1 a G3 supergiant. These stars are not physically associated, but appear "double" merely by chance alignment.

Each component of $\alpha^{1,2}$ Cap has a dimmer, closer companion as well. Alpha^2, the bright giant, has an 11th magnitude partner some 6.6″ away in p.a. 172° (1959). Alpha^1, the bright supergiant, has two physical companion stars. A ninth-magnitude star lies 45.4″ away at p.a. 221° (1932), while a 13th magnitude star lies 44.3″ distant in p.a. 182° (1960). After enjoying the wide pair of α^1 and α^2 Cap, "zoom in" on each star for some high-power observing and try to spot their smaller companions.

About 2½° south of Alpha^{1,2} Cap is another double star, **Beta** (β) **Capricorni**. Beta Cap contains stars shining at magnitudes 3.4 and 6.2; they are easily split with any telescope because of the 3½′ gap between them. And even a small telescope shows off their colors — white for the dazzling primary and blue for the secondary.

Two variable stars reside several degrees west of Beta Cap — **R Capricorni** and **TW Capricorni**. R Cap is a typical long-period variable whose range of magnitudes between 9.4 and 14.9 and period of 345 days combine to make observing it an ideal long-term project. You can follow R Cap with binoculars through much of its cycle, but at minimum it fades below the light-gathering ability of most backyard telescopes. TW Cap is a bright Cepheid variable with a smaller range of magnitudes — 9.7 to 10.5 — and a period of 28.6 days. This is a fine binocular variable, but you'll have to become adept at comparing measurements in tenths of a magnitude to check its variation. The range of less than one magnitude isn't great enough to make the star's variation obvious, so check it against nearby stars of similar brightness. Over the course of a month, you'll see it fade and return to normal brightness again.

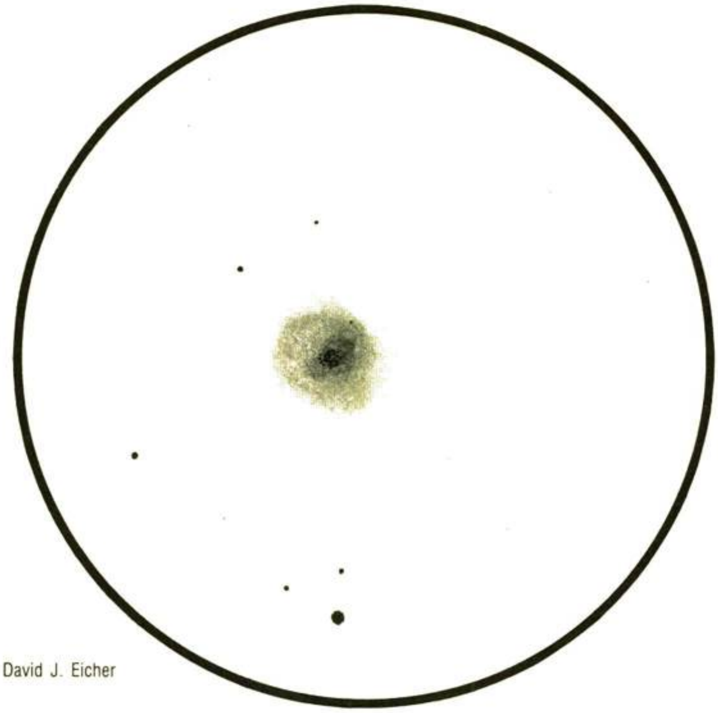
Three degrees south of Beta Cap is the unusual variable star **RW Capricorni**, a bright eclipsing binary much like the more renowned Beta Lyrae. RW Cap varies between magnitudes 9.8 and 11.0 over 3.39 days, so you'll need two or three successive clear nights in order to view it. The range of variance — a little over a magnitude — suggests that you should observe with binoculars.

Southeast of Beta and RW Cap and near the ecliptic is a clump of two bright double stars and a faint galaxy. Unlike Alpha^{1,2} and Beta Cap, these double stars — **Pi** (π) **Capricorni** and **Omicron** (o) **Capricorni** — are best viewed with 100x to 150x. Omicron is the easiest to resolve with its magnitude 6.1 and 6.6 components separated by 21.9″ in p.a. 239° (1955). Both stars are bluish-white and stand out easily at low or medium powers. Pi's stars, on the other hand, are separated by only 3.2″ in p.a. 148° (1955). These magnitude 5.3 and 8.9 components differ enough in brightness to make splitting difficult unless seeing is steady. Lying adjacent to these stars is **NGC-6712**, a 14th magnitude barred

For information on naked-eye sky viewing, including planets, constellations, and mythology, see **Eye on the Sky**.

M-30

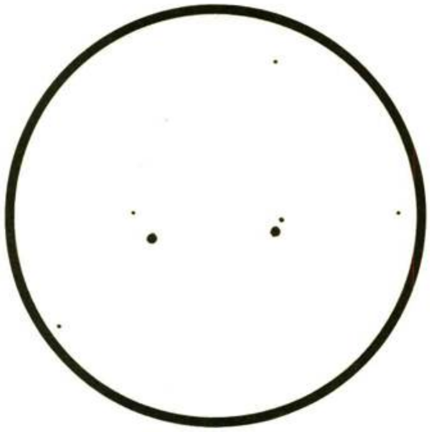
8-inch f/10 SCT
50x



Sketch by David J. Eicher

$\alpha^{1,2}$ Cap

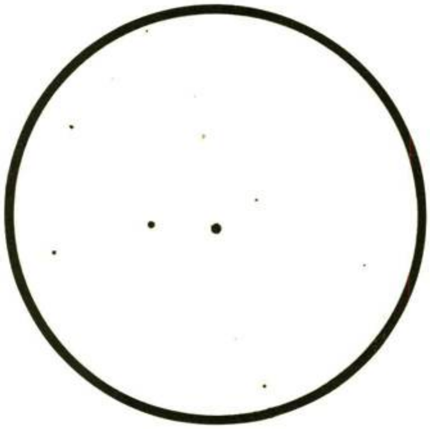
4-inch reflector
35x



Sketch by James Mullaney

β Cap

3-inch reflector
30x



Sketch by James Mullaney

spiral galaxy measuring 1.6′ x 1.3′ across. With high magnification on a 10-inch telescope, it appears as a tiny nebulosity — a smudge of grainy light.

Lying in central Capricornus is the semiregular variable star **RS Capricorni**, which varies between magnitudes 8.3 and 10.3 over a period spanning 345 days. Although its magnitude range isn't as dramatic as that of R Cap's, the long period provides ample time to follow the star's changes regardless of weather or other hindrances. This is another fine binocular star, but a small telescope will do just as well for comparing it with nearby stars of known constant brightness.

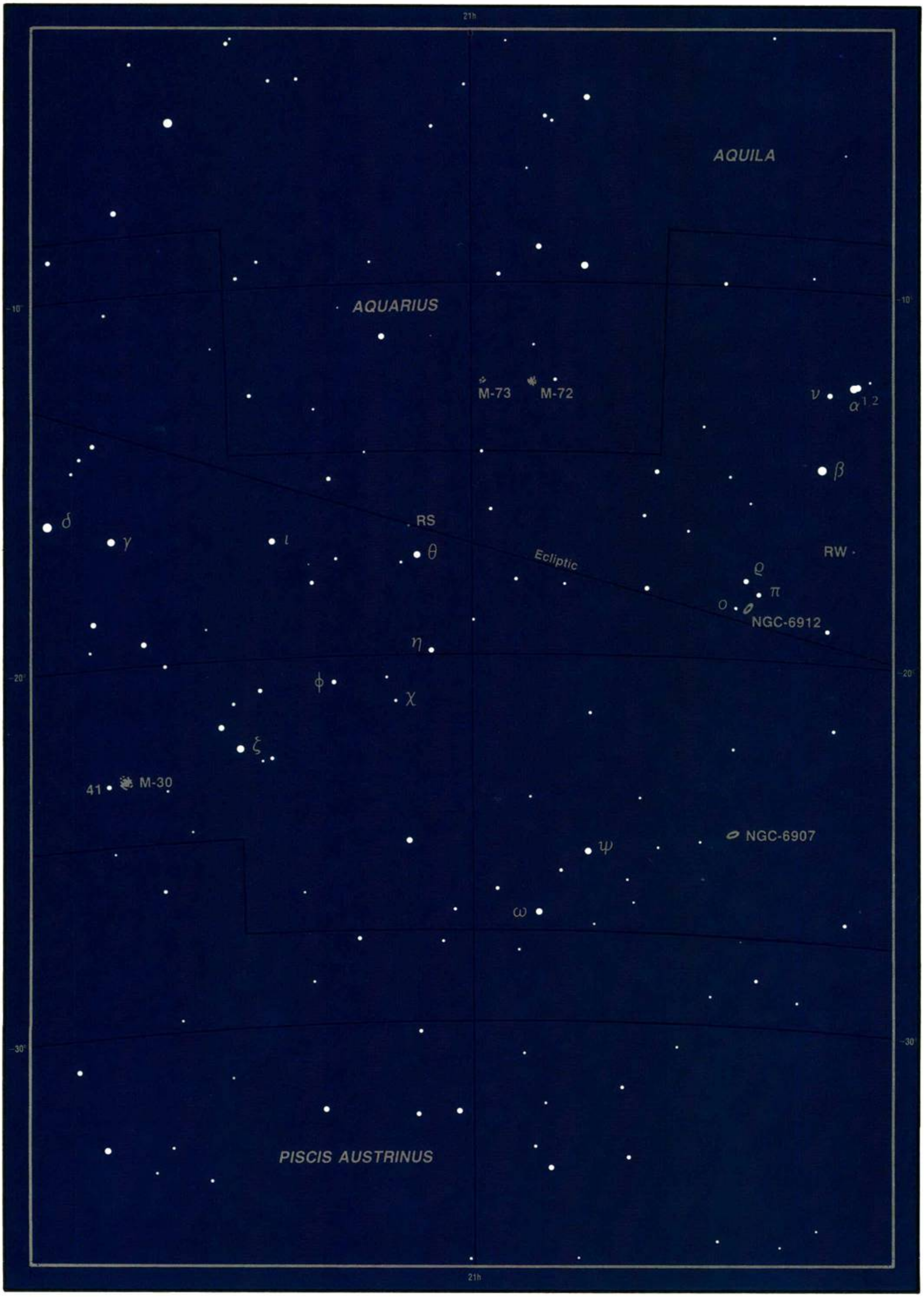
The eastern edge of Capricornus holds the bright double star **Delta (δ) Capricorni**. Appearing as a solitary star to the naked eye, modest optical aid reveals a faint companion unknown to many observers. The primary is a bluish-white magnitude 2.9 eclipsing binary around which a 12th magnitude companion orbits at a distance of nearly 2′. The primary's magnitude varies slightly over a period of less than one day. On a dark transparent night, aim your telescope at Delta Cap and insert a high-power eyepiece: you'll see the tiny dwarfish companion as a speck, nearly overpowered by the brilliant primary star.

The second brightest deep-sky object in Capricornus after M-30 is the 11th magnitude galaxy **NGC-6907**. This barred spiral measures 3.4′ x 3.0′ across and is bright enough to be viewed with a 6-inch telescope. A 10-incher shows it as a roundish patch with a bright middle, whereas large backyard telescopes reveal an evenly-illuminated, wispy halo of gray light around a bright oval nucleus.

Object	M#	Type	R.A. (2000)	Dec.	Mag.	Size/Sep./Per.	H
R		LPV	20h 10.8m	−14°16′	9.4↔14.9	345d	
TW		CV	20h 13.8m	−13°51′	9.7↔10.5	28.6d	
α		★^{2}	20h 17.6m	−12°30′	3.6,4.2	377.7″	
RW		EV	20h 17.8m	−17°41′	9.8↔11.0	3.39d	
β		★^{2}	20h 21.0m	−14°47′	3.4,6.2	205.3″	
NGC-6907		§B	20h 25.1m	−24°49′	11.3	3.4′x3.0′	S(B)b
NGC-6912		§B	20h 26.9m	−18°38′	14:	1.6′x1.3′	SBc
π		★^{2}	20h 27.3m	−18°13′	5.3,8.9	3.2″	
o		★^{2}	20h 29.9m	−18°35′	6.1,6.6	21.9″	
RS		SRV	21h 07.2m	−23°55′	8.3↔10.3	340d	
NGC-7099	M-30	●	21h 40.4m	−23°11′	7.5	11.0′	
41		★^{2}	21h 42.0m	−23°16′	5.3,11.5	5.5″	
δ		★^{2}	21h 47.0m	−16°08′	2.9,12.6	118.9″	

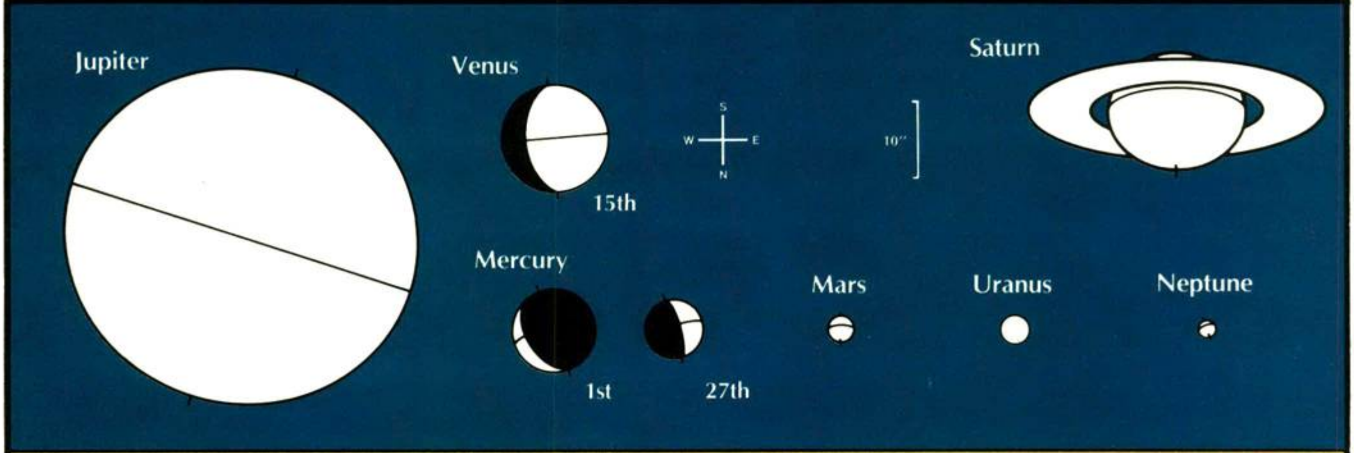
H = Hubble classification type for galaxies

★^{2}	*Double Star*
LPV	*Long Period Variable*
SRV	*Semi-Regular Variable*
EV	*Eclipsing Variable*
CV	*Cepheid Variable*
●	*Globular Star Cluster*
§B	*Barred Spiral Galaxy*

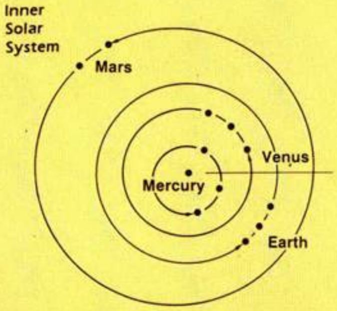

21h
AQUILA
-10°
AQUARIUS
M-73
M-72
ν
α 1 2
β
RS
Ecliptic
RW
δ
γ
ι
θ
ϱ
π
ο
NGC-6912
η
-20°
ϕ
χ
ζ
41
M-30
NGC-6907
ψ
ω
-30°
PISCIS AUSTRINUS
21h

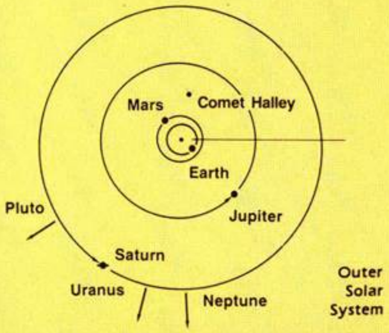
Planetary Data

August 1985


Jupiter
Venus
15th
S
W
E
N
10″
Saturn
Mercury
1st
27th
Mars
Uranus
Neptune

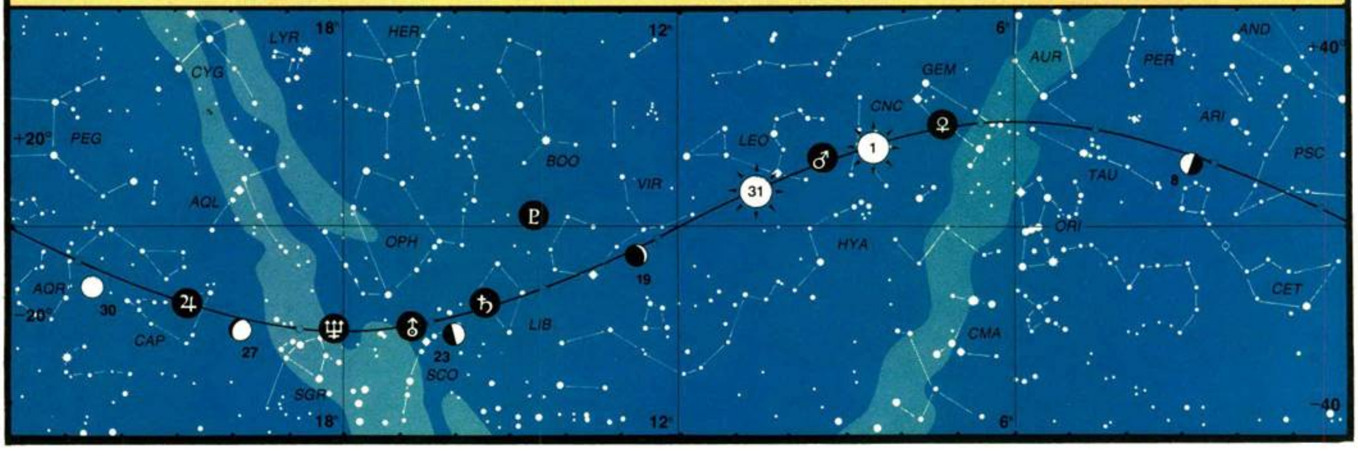
		Date	Mag.	Angular Size	% Illum.	Distance (AU) from: Earth	Distance (AU) from: Sun	Longitude: Heliocentric	Longitude: Ecliptic	R.A. (2000.0)	Dec.
Sun		1	−26.7	31.6′	—	1.01	—	—	128°42.2′	8h 45.3m	18°02.2′
		15	−26.7	31.6′	—	1.01	—	—	142°07.4′	9h 38.7m	14°04.6′
		31	−26.7	31.7′	—	1.01	—	—	157°32.7′	10h 37.7m	8°40.1′
Mercury	☿	1	2.3	10.8″	12%	0.63	0.45	286°17.7′	144°35.9′	9h 42.7m	9°11.1′
		15	3.7	10.5″	2%	0.64	0.39	333°33.4′	135°39.0′	9h 06.6m	12°17.1′
		31	−0.5	6.8″	54%	0.99	0.31	54°33.8′	140°08.9′	9h 29.3m	15°06.3′
Venus	♀	1	−4.0	15.4″	71%	1.08	0.72	23°27.7′	88°39.2′	5h 54.1m	21°36.9′
		15	−4.0	14.2″	76%	1.18	0.72	45°51.3′	104°46.4′	7h 03.6m	21°34.2′
		31	−4.0	13.0″	81%	1.28	0.72	71°33.5′	123°36.2′	8h 23.4m	19°11.7′
Mars	♂	10	1.7	3.5″	100%	2.64	1.64	125°49.1′	130°24.2′	8h 52.7m	18°42.8′
		20	1.8	3.6″	100%	2.63	1.65	130°17.4′	136°48.3′	9h 18.4m	16°53.7′
Jupiter	♃	15	−2.8	48.2″	100%	4.08	5.08	312°56.9′	310°53.5′	20h 54.4m	−18°20.8′
Saturn	♄	15	0.5	16.7″	100%	9.90	9.95	237°38.8′	232°00.9′	15h 20.6m	−16°16.2′
Uranus	⛢	15	5.6	3.8″	100%	18.69	19.09	256°48.8′	254°20.1′	16h 51.4m	−22°32.7′
Neptune	♆	15	7.9	2.3″	100%	29.61	30.25	272°33.1′	271°20.3′	18h 05.4m	−22°17.8′
Pluto	♇	15	13.8	0.1″	100%	30.07	29.76	214°09.9′	212°32.0′	14h 23.5m	3°11.0′


Inner Solar System
Mars
Venus
Mercury
Earth


Mars
Comet Halley
Earth
Pluto
Jupiter
Saturn
Uranus
Neptune
Outer Solar System

Moon Data

Last Quarter..........August 8 at 18h29m
New Moon.........August 16 at 10h06m
First Quarter..........August 23 at 4h36m
Full Moon...........August 30 at 9h27m
Last Quarter.......September 7 at 12h16m
New Moon......September 14 at 19h20m
Apogee: August 8 at 2h25m...404,117 km.
Perigee: August 20 at 4h21m..367,360 km.


18°
LYR
HER
12°
6°
AUR
AND
+40°
CYG
GEM
PER
CNC
ARI
+20°
PEG
LEO
BOO
1
PSC
TAU
VIR
31
8
AQL
ORI
OPH
HYA
19
AQR
CET
−20°
30
LIB
CAP
27
23
CMA
SCO
SGR
18°
12°
6°
−40

From a latitude of 45° south, NGC-5128 — the enigmatic galaxy also known as radio source Centaurus A — passes nearly overhead. David Curtis of Dunedin, New Zealand used an 8-inch f/5 Newtonian, VR-1000 film, and a 28-minute exposure to capture it.

Mercury

During the last half of August and the first two weeks of September, Mercury appears in the morning sky. Greatest western elongation is on August 28th (inferior conjunction is August 10th), but it reaches peak elevation (8°, 45 minutes before sunrise) on August 30th. The planet will be at least 5° high in the northeast from August 22nd to September 7th.

In a telescope with medium magnification (100x to 150x), you can watch Mercury pass from crescent phase, through half-lit at elongation, to become gibbous as it sinks into the dawn glow, heading toward superior conjunction on September 22nd.

Venus

Now at its highest elevation for this apparition, Venus dominates the morning sky (except, briefly, when the Moon passes by on the 13th). Like Mercury, Venus shows phases that mimic the Moon's. But unlike Mercury, its changes happen far more slowly. Between now and the end of the year, Venus will become smaller in your telescope's eyepiece and steadily more gibbous. Mercury races through an apparition in a few weeks, but Venus takes *months*.

This means that now Venus appears pretty much the same on any clear morning — and it isn't until several weeks have passed that you suddenly notice how much it has changed.

Mars

Moving eastward in Cancer, Mars still lies fairly close to the Sun; sharp-eyed planet watchers, however, can pick up the first-magnitude object low in the east-northeast by month's end. On the 30th, Mars will be at nearly the same azimuth as Mercury, but with half its elevation. Mars is a long way from being a good telescopic object, but be patient: the coming opposition (about a year away — July 10, 1986) will be one of the best of the past 18 years.

Minor Planets

1 Ceres is still lost in the solar glare this month.

2 Pallas (magnitude 9.0) will pass 1° 3′ north of Rigel at 5h26m UT on August 27th. Its positions:

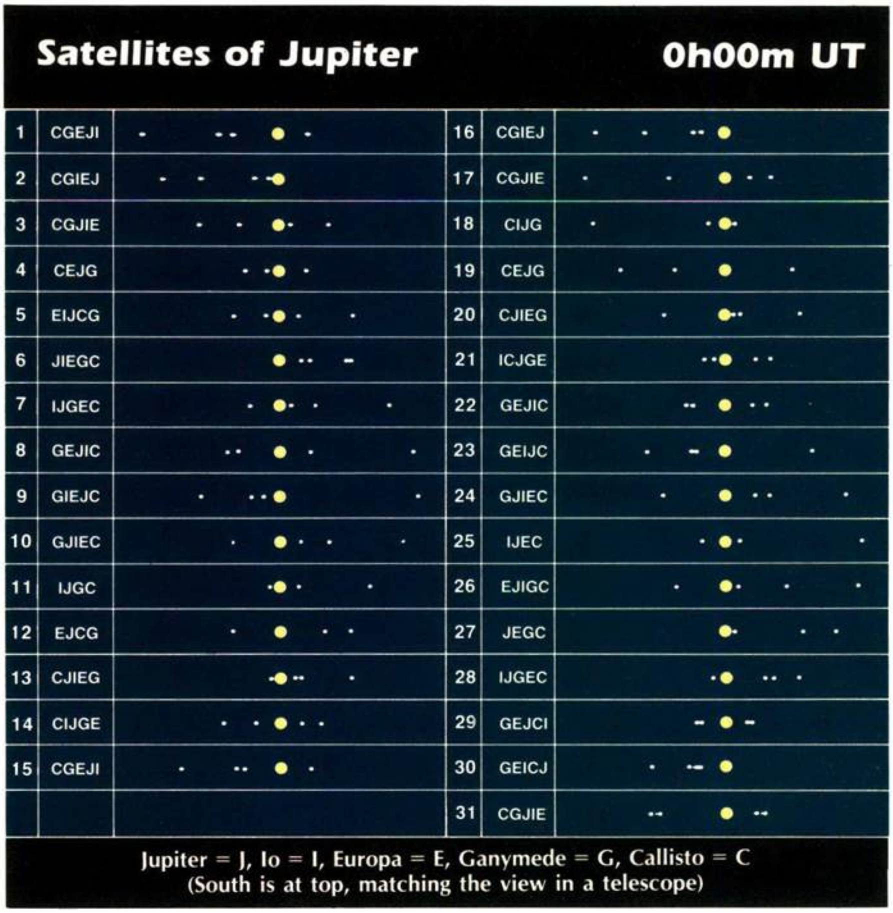
10th: 4h 47m 19s, −4° 20.4′
20th: 5h 03m 22s, −5° 52.3′

Pallas rises around 3:30 a.m. local daylight time on the 15th.

3 Juno (11.3) is moving eastward in central Virgo about 6° north of the ecliptic. Its positions:

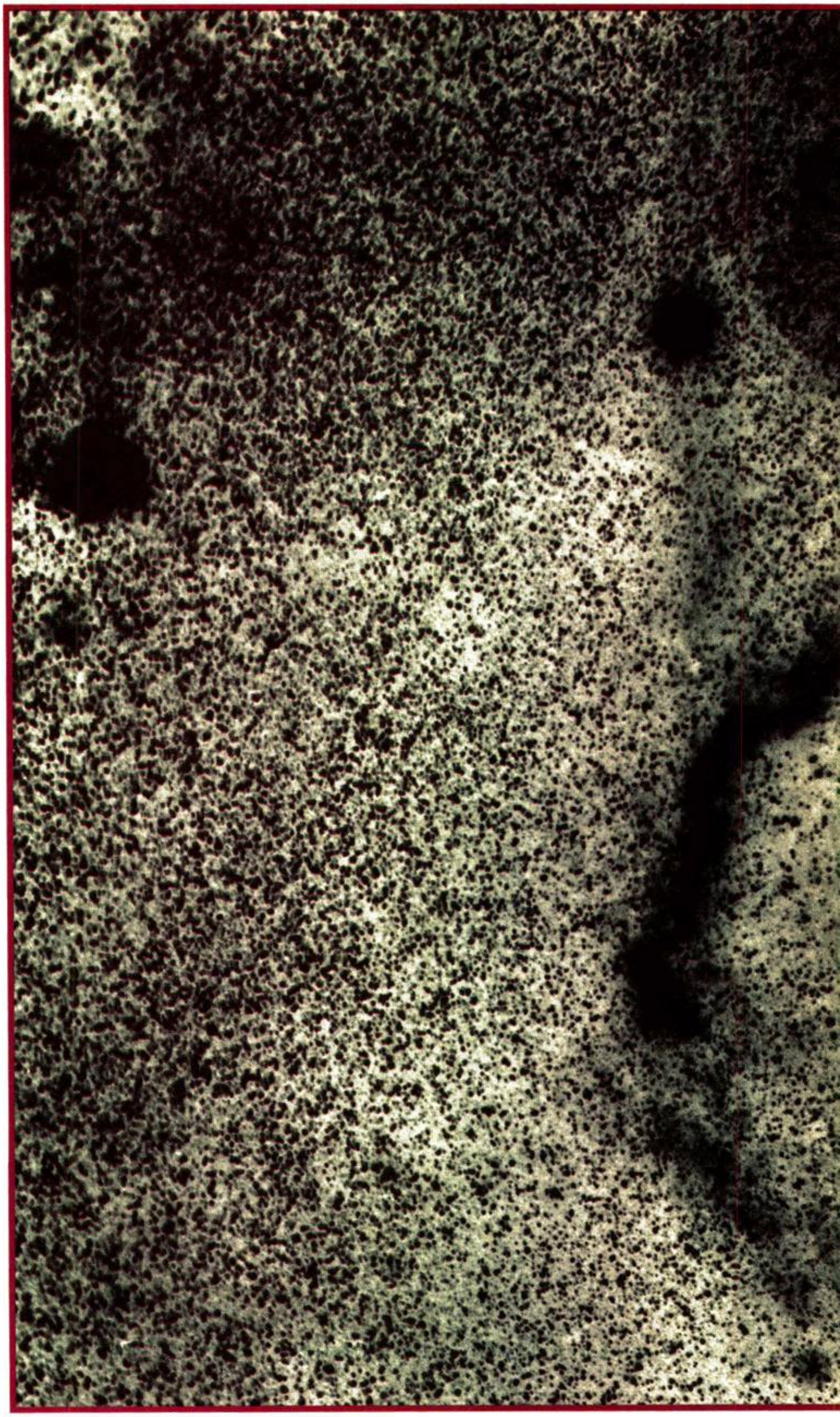
10th: 12h 55m 23s, 1° 29.2′
20th: 13h 06m 12s, 0° 23.4′

Juno sets around 10 p.m. local daylight time at mid-month.



Satellites of Jupiter **0h00m UT**

Jupiter = J, Io = I, Europa = E, Ganymede = G, Callisto = C
(South is at top, matching the view in a telescope)



This shot of the red nebulosity in Orion — August's "Best Astro-Photo" — was taken with modest equipment. Gregory Field piggybacked his 35mm camera (50mm lens at f/2.8) on an 8-inch SCT; the exposure (hypered 2415, Hα filter) ran 50 minutes. Developing the film in D-19 for 5 minutes, he copied it onto High-Contrast Copy film and then onto grade 5 paper, winding up with a stunning negative print. Note the Rosette Nebula (left edge), the Lambda Orionis "cloud" (top), and the broad arc of Barnard's Loop (center).

4 Vesta (7.4) is moving eastward in Libra not far west of Saturn, which it will pass about a degree north of on September 16th. Its positions:

10th: 14h 26m 37s, −9° 36.3′
20th: 14h 41m 11s, −11° 21.5′

Vesta sets around 11:30 p.m. local daylight time on the 15th.

For convenience in plotting their motions on a star atlas, all minor planet positions are for the epoch 2000.0.

Jupiter

Jupiter is at opposition on August 4th in Capricornus. It is now at its best and brightest for viewing. Try to observe Jupiter as often as possible; in this way, you'll accustom your eye to spotting the subtle details of its cloud belts.

The most dramatic jovian moon event this month is the partial eclipse of Europa by Ganymede between 10h13m and 10h28m UT on the 6th. The event takes place 4.7 Jupiter diameters east of the planet. Europa's drop in brightness should be more than 4 magnitudes. Use medium magnification on your telescope. Those who must view the event in morning twilight will find a red filter helps to darken the sky.

Saturn

As darkness falls August 1st, Saturn is about 30° above the south-southwestern horizon; by the end of the month, its elevation will be 20°. For observers, this means Saturn is already best placed for viewing as soon as the sky gets dark — and its visibility will worsen steadily as the evening goes on and the planet sinks into the haze.

Apart from necessity, observing during twilight is a good way to discern low-contrast features on bright objects like Saturn. Experienced planetary observers have long used the technique to see faint surface details normally all but invisible.

Uranus

Uranus is at the western end of its retrograde loop on August 22nd, therefore it spends the entire month nearly stationary. Use the finder chart in the January issue for locating it. In your telescope, Uranus' bright greenish disk is instantly recognizable as non-stellar — even at relatively low magnification.

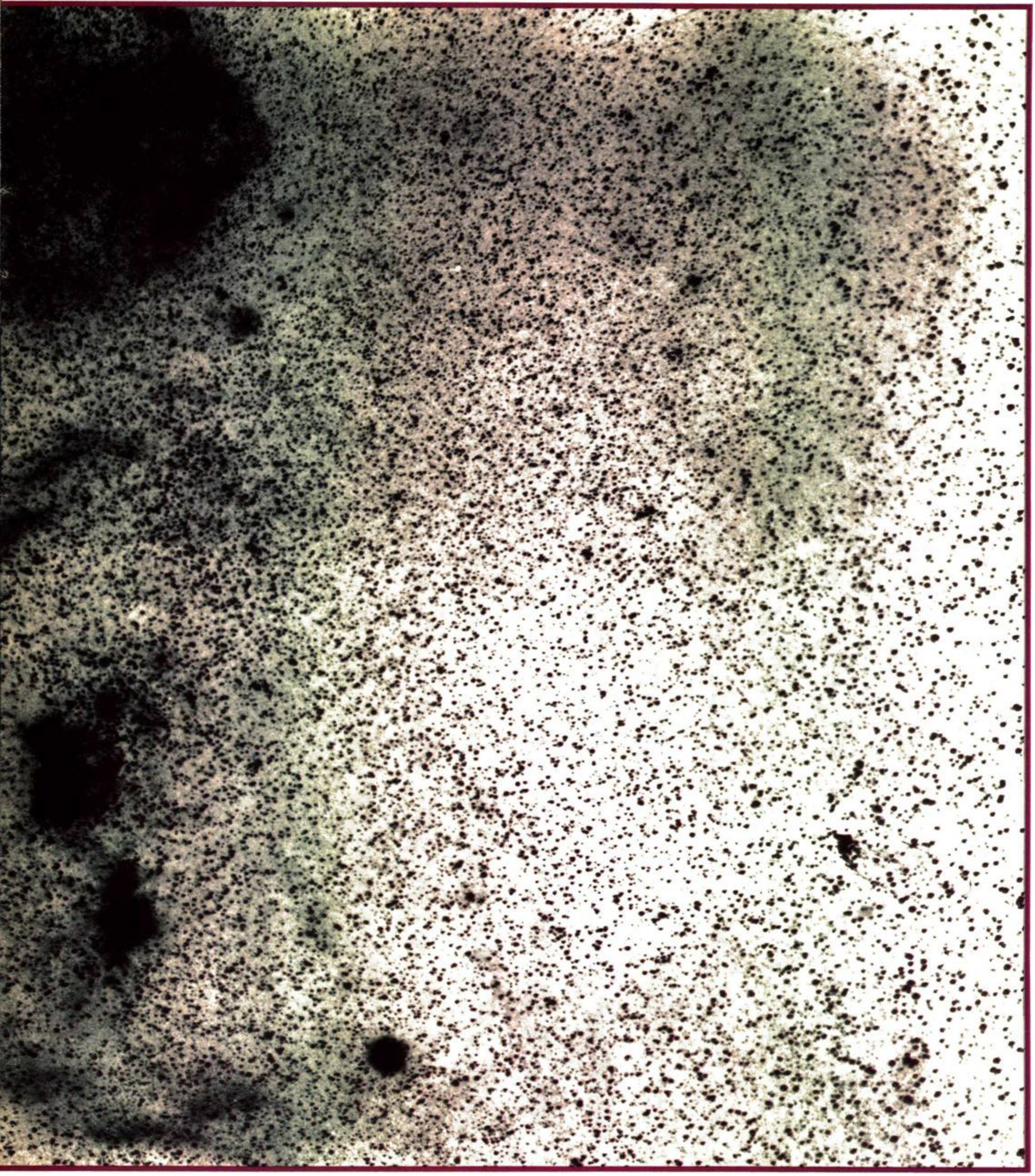
Neptune

In Sagittarius, Neptune is also slowing toward its western stationary point, which it will reach on September 12th. Neptune is easier to locate than Uranus because it lies near three Messier objects: M-8, M-20, and M-21.

Find the planet by scanning from M-8 (the Lagoon Nebula) to M-20 (the Trifid) — you might describe this as taking the scenic route — and then sweeping northeastward from M-20 to M-21 (a 12 arc-minute diameter, 7th-magnitude open star cluster). Neptune lies about 20′ of arc northeast of the cluster (on the side away from the Trifid Nebula); it has a 2.3″ diameter disk, and is at 8th magnitude.

Meteors

August is Perseid month, and peak activity this year comes at 13h UT on the 12th. This is during daylight for North



America, so you'll want to be watching on the nights of the 11th/12th and 12th/13th, at least. The Moon (four days past Last Quarter) will be a problem, but shouldn't seriously affect the brighter Perseids. At a dark-sky site, expect to see a couple of Perseids a minute after midnight.

While you're out catching Perseids, also keep alert for meteors from the Delta Aquarid stream. This shower peaks in late July, but its peak is extremely broad and Delta Aquarids can be seen (albeit in sparse numbers) all through August.

Comet Halley

Halley is moving eastward in northern Orion. During August, it will be about a degree south of Chi^1 and Chi^2 ($\chi^{1\,2}$) Orionis. Its positions (epoch 2000.0):

10th: 5h 58m 26s, 19° 01.6′
20th: 6h 03m 55s, 19° 10.4′

Halley is at 14th magnitude by mid-month. See the finder map in Gazer's Gazette, which starts on page 35.

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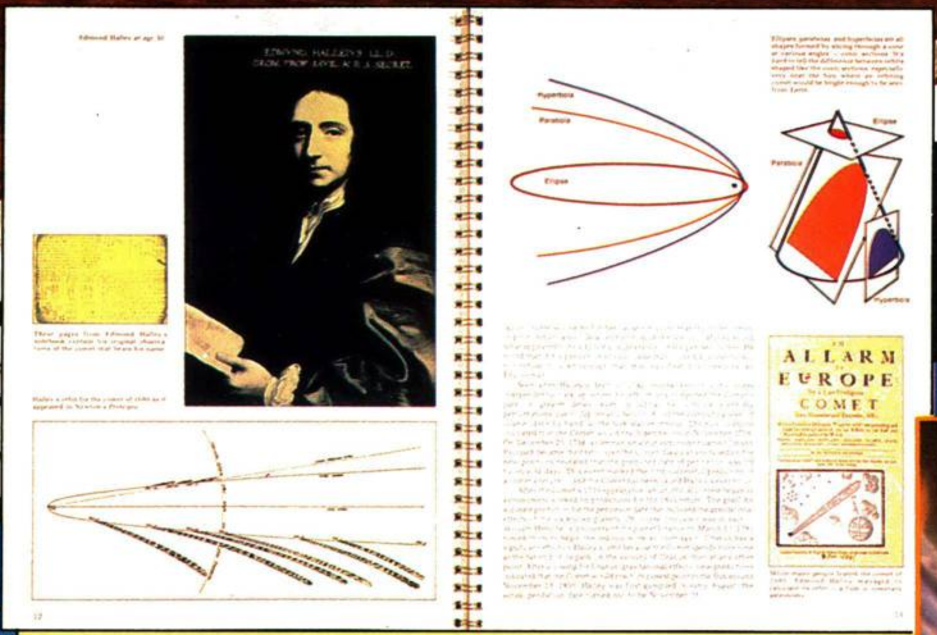
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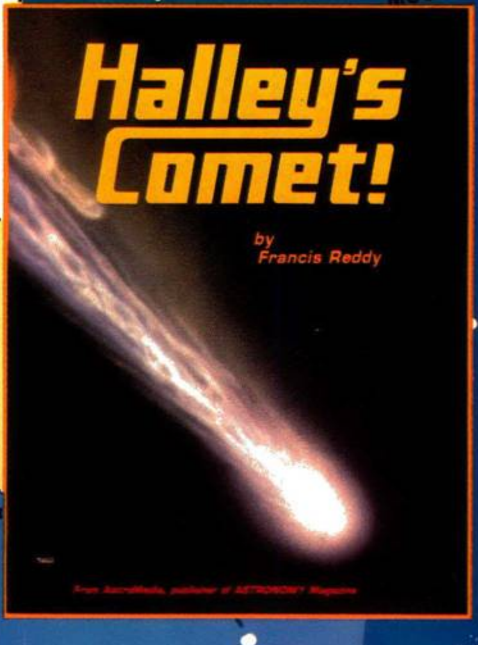
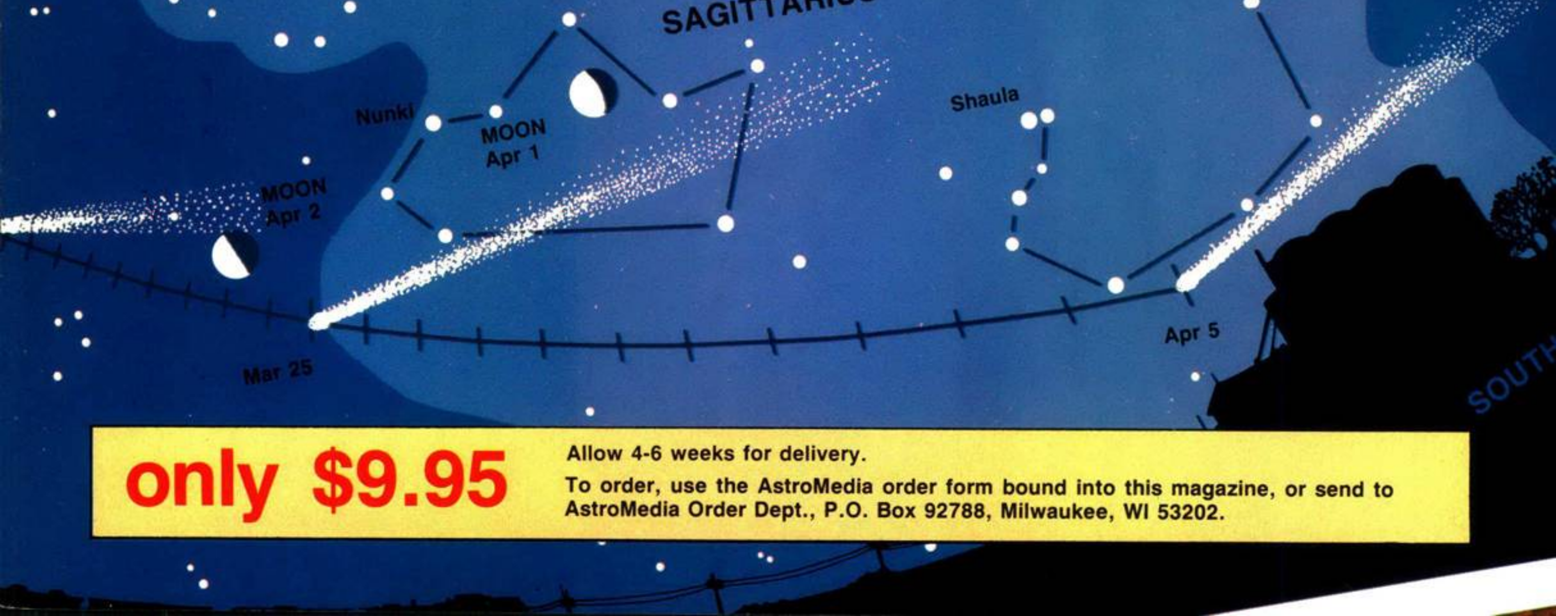


Halley's Comet!

by
Francis Reddy

Maps for +40°, +55°, −35°


Latitude 40° N
Morning Twilight
MOON
AQU
MARS
Mar 25
Apr 5
SAGITTARIUS
Nunki
MOON
Apr 1
MOON
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Shaula
Mar 25
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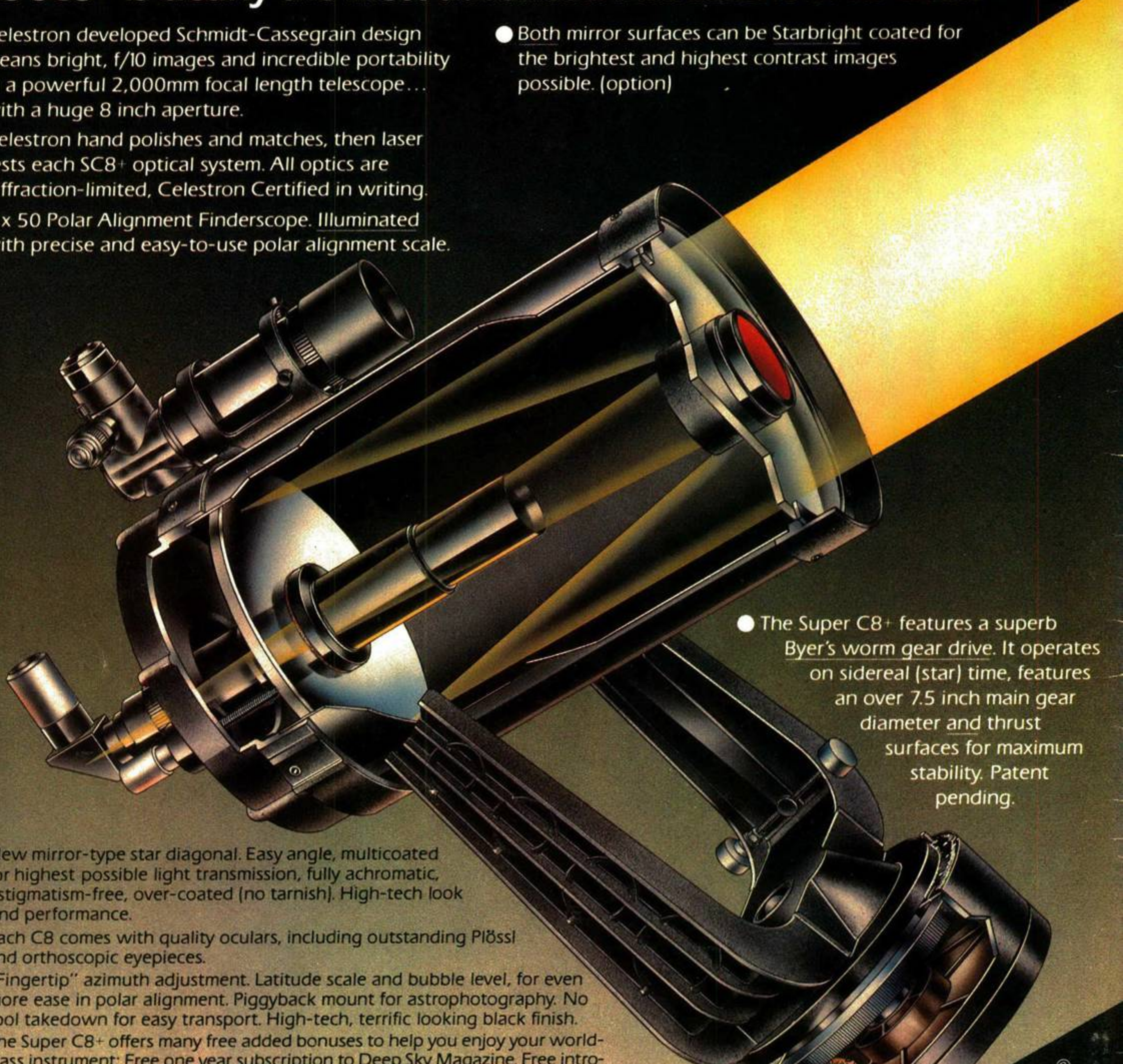

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